



Crypto Library

Microchip Libraries for Applications (MLA)

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Crypto Library

1 Crypto Library

1.1 Introduction

This library provides symmetric and asymmetric cryptographic encryption and decryption functionality for the Microchip family of microcontrollers with a convenient C language interface.

Description

This library provides symmetric and asymmetric cryptographic encryption and decryption functionality for the Microchip family of microcontrollers with a convenient C language interface. This crypto library provides support for the AES, TDES, XTEA, ARCFOUR, and RSA algorithms.

AES, TDES, and XTEA are all symmetric block cipher algorithms, meaning they encrypt/decrypt fixed-length blocks of data and use the same key for encryption and decryption. To provide a complete model of security, these algorithms should be used with one of the provided block cipher modes of operation.

AES is one of the most widely used ciphers available today. It uses 128-, 192-, or 256-bit keys to encrypt 128-bit blocks. AES supports the Electronic Codebook (ECB), Cipher-Block Chaining (CBC), Cipher Feedback (CFB), Output Feedback (OFB), Counter (CTR), and Galois/Counter Mode (GCM) modes of operation.

TDES (Triple DES), based on the DES cipher, is a precursor to AES, and is maintained as a standard to allow time for transition to AES. **TDES is not recommended for new designs.** TDES uses 56-bit DES keys (64-bits, including parity bits) to encrypt 64-bit blocks. TDES actually uses up to three distinct keys, depending on the keyring option that the user is using (hence the name, Triple DES). TDES supports the Electronic Codebook (ECB), Cipher-Block Chaining (CBC), Cipher Feedback (CFB), and Output Feedback (OFB) modes of operation.

XTEA gained popularity because it was easy to implement. It uses 128-bit keys to encrypt 64-bit blocks of data. **XTEA is not recommended for new designs.**

ARCFOUR is a symmetric stream cipher, encrypting or decrypting one byte of data at a time using a single key. It supports variable key lengths between 40 and 2048 bits. **ARCFOUR is not recommended for new designs.**

RSA is an asymmetric cipher used to encrypt/decrypt a block of data that matches the key size. This library supports 512-, 1024-, and 2048-bit RSA keys. RSA uses a public key scheme in which a user makes one key widely available (the "public key"). Anyone can use this public key to encrypt a block of data, but only someone who possesses the corresponding "private key" for that public key can decrypt the data. The RSA algorithm takes a large number of instructions to decrypt data relative to symmetric key algorithms like AES or ARCFOUR; for this reason it's usually used as part of a key exchange protocol to exchange symmetric keys from a faster algorithm that will then be used to transmit other data.

1.2 Legal Information

This software distribution is controlled by the Legal Information at www.microchip.com/mla_license

1.3 Release Notes

Release notes for the current version of the Crypto module.

Description

CRYPTO Library Version : 1.00

This is the first release of the library.

Tested with MPLAB XC16 v1.11.

1.4 Using the Library

Describes how to use the crypto library.

Description

This topic describes the basic architecture of the crypto library and provides information and examples on how to use it.

Interface Header File: crypto.h

The interface to the crypto library is defined in the "crypto.h" header file. Any C language source (.c) file that uses the crypto library should include "crypto.h". Several sub-header files are provided for individual algorithms. These have the format "[algorithm].h" (e.g. "aes.h"). Additional header files are provided for the block cipher modes of operation; the generic header file for this is "block_cipher_modes.h" and each specific mode has its own header, with the form "block_cipher_mode_xxx.h," where "xxx" is the mode (ecb, cbc, cfb, ofb, ctr, gcm).

Note that depending on which implementation of the RSA module is used, it may require the big integer math library (bigint). The big integer math library is included with this crypto library; any C language source (.c) file that uses the big integer math library should include "bigint.h."

1.4.1 Abstraction Model

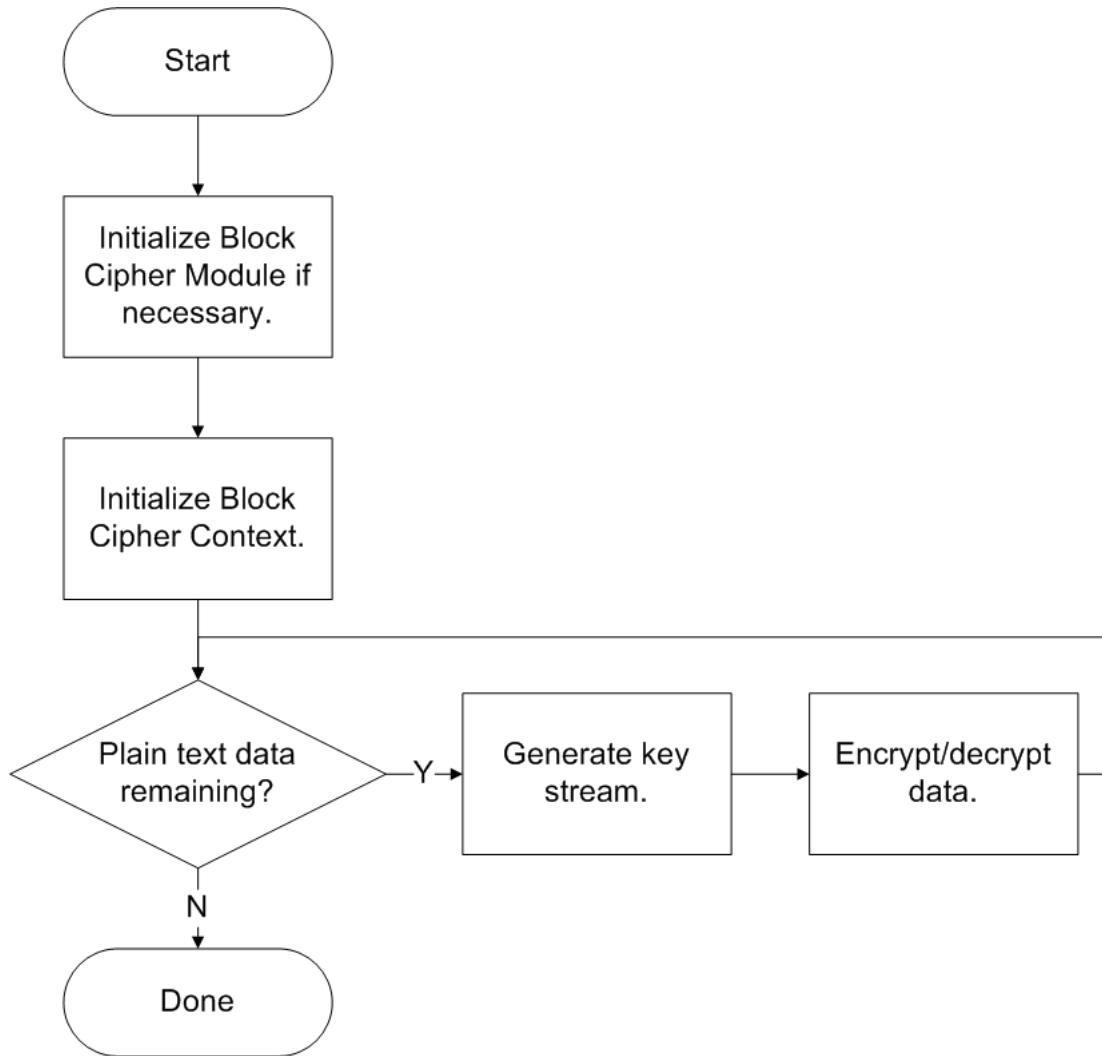
This library provides the low-level abstraction of the crypto module on the Microchip family of microcontrollers with a convenient C language interface. This topic describes how that abstraction is modeled in the software and introduces the library interface.

Description

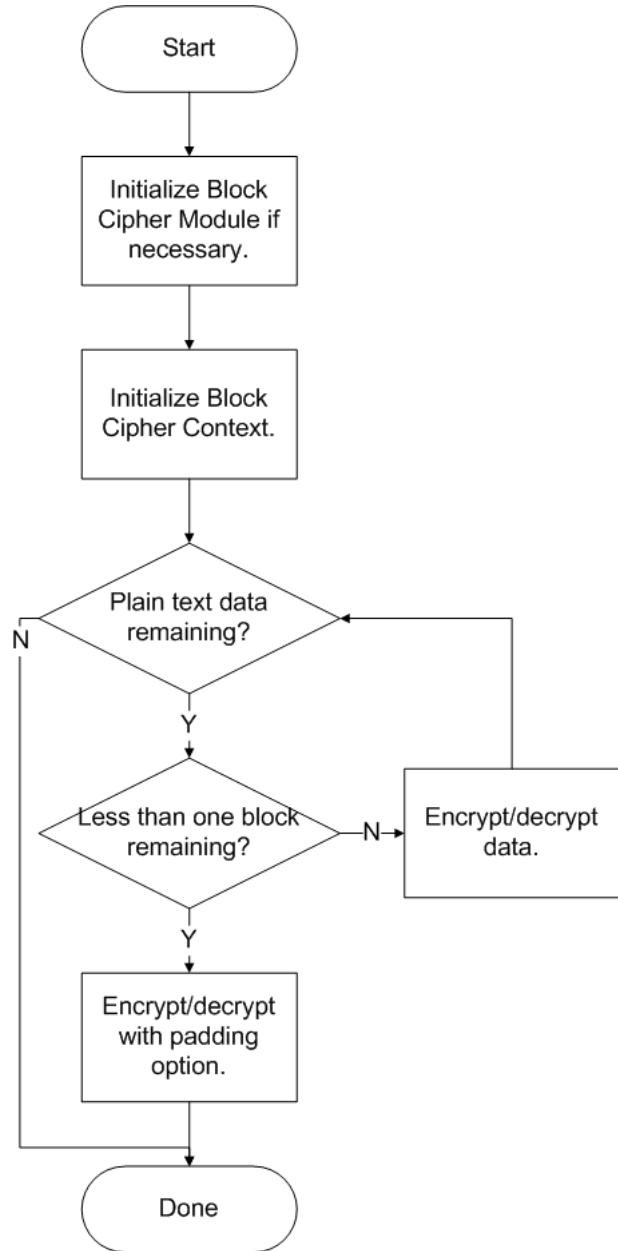
Non-authenticating Block Cipher Modules

Depending on the mode of operation used with a block cipher, the message may be padded, initialized with an initialization vector, or use feedback from previous encryption blocks to provide additional security. The currently available modes can be grouped into two categories: modes that use keystreams (OFB, CTR), and modes that do not (ECB, CBC, CFB). The keystream modes use initialization data (provided by feedback for OFB), but that data doesn't depend on the plaintext or ciphertext used for the previous encryption or decryption. For this reason, a keystream can be generated before the plaintext or ciphertext is available and then used to encrypt/decrypt a variable-length block of text when it becomes available. The other modes require whole blocks of data before they can be encrypted/decrypted.

Block Cipher Mode Module Software Abstraction Block Diagram (Keystream modes)



Block Cipher Mode Module Software Abstraction Block Diagram (Non-keystream modes)



Authenticating Block Cipher Modes

Galois/Counter Mode (GCM) is a special case. It provides encryption/decryption and authentication for a set of data. The encryption/decryption uses operations that are equivalent to counter mode, but the authentication mechanism operates on whole blocks of data. For this reason, GCM uses keystreams to encrypt/decrypt data, but must also be padded at the end of a set of encryptions/decryptions to generate an authentication tag. GCM can also authenticate a set of data that will not be encrypted. For example, if you have a packet of data with a header and a payload, you could use GCM to authenticate the header and payload with one authentication tag, but only encrypt the payload.

GCM operates on data in a specific order. First, data that is to be authenticated but not encrypted/decrypted is processed. If necessary this data is padded to one block size. For an encryption, the plaintext is then encrypted and the resulting ciphertext is authenticated. For a decryption, the ciphertext is authenticated, and then decrypted into a plaintext. The authenticated ciphertext is also padded. Finally, the lengths of the non-encrypted/decrypted data and ciphertext are authenticated, and an authentication tag is generated.

GCM Authenticated Data Organization

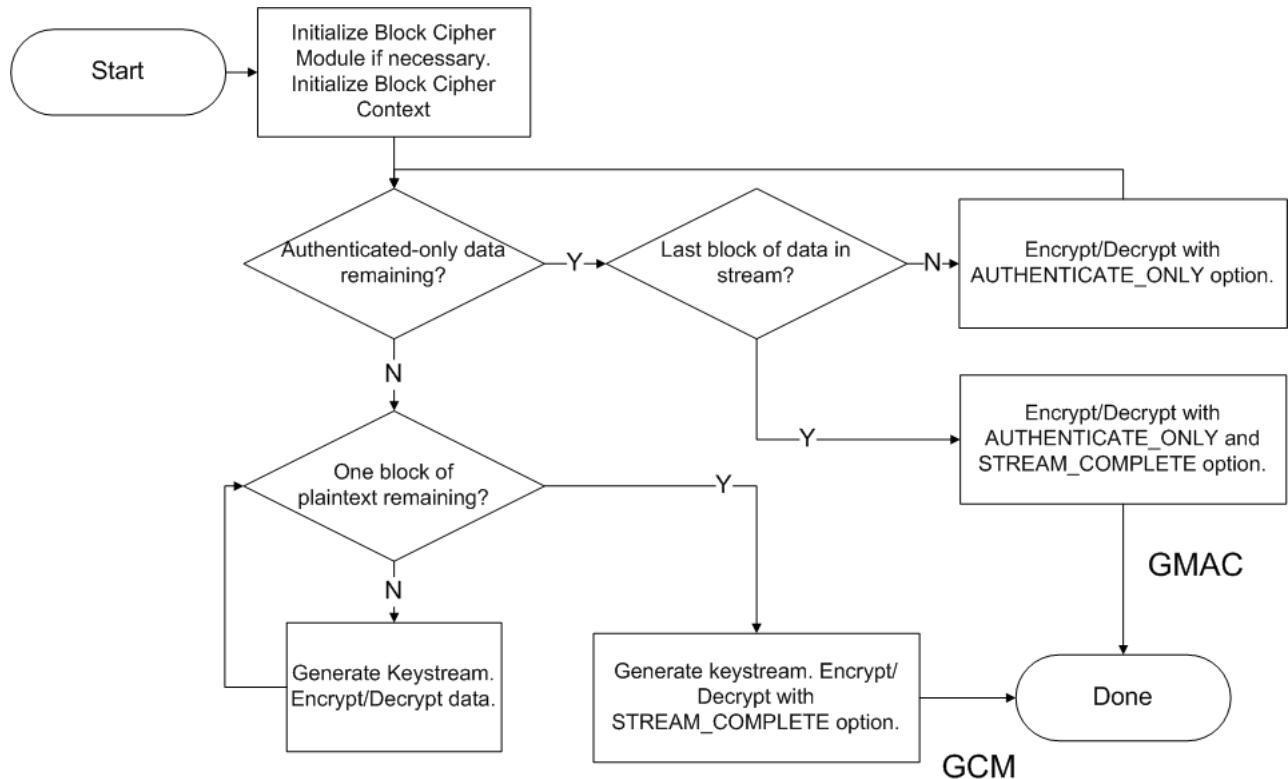
Authenticated data (A)	0	Authenticated + encrypted data (C)	0	len (A)	len (C)
------------------------	---	------------------------------------	---	---------	---------

The GCM module will take care of padding automatically, as long as the user specifies which operation should be performed on the data. When the user first calls `BLOCK_CIPHER_GCM_Encrypt` or `BLOCK_CIPHER_GCM_Decrypt`, he or she can optionally specify one of the options as `BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY`. This will indicate to the GCM module that the data being passed in should be authenticated, but not encrypted or decrypted. If this option is specified, the user does not need to specify an output buffer (the `cipherText` parameter for `Encrypt`, or the `plainText` parameter for `Decrypt`). Once the user has passed in all data that must be authenticated but not encrypted/decrypted, they can call the `Encrypt` or `Decrypt` function without the `AUTHENTICATE_ONLY` option. This will automatically generate zero-padding for the block of non-encrypted data.

If the user calls the `Encrypt` or `Decrypt` function without the `AUTHENTICATE_ONLY` option, any data they pass in to that call (and every subsequent call) will be both authenticated *and* encrypted or decrypted. Once the user is finished authenticating/encrypting/decrypting data, he or she will call the `Encrypt` or `Decrypt` function with the `BLOCK_CIPHER_OPTION_STREAM_COMPLETE` option. This will indicate to the GCM module that all encryption and decryption has been completed, and it will pad the encrypted data with zeros (and with the lengths of the authenticated-only and the encrypted data) and calculate the final authentication tag. If the data is being encrypted, this tag will be returned to the user. If the data is being decrypted, this tag will be compared to a tag provided by the user and an error will be returned in the event of a mismatch.

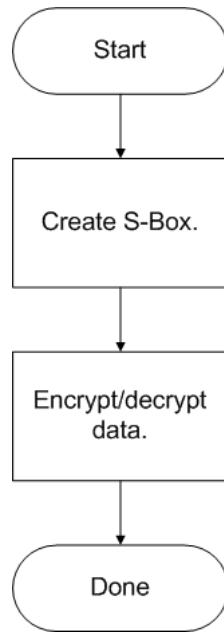
Note that the user doesn't necessarily need to provide data to encrypt/decrypt. If the user only provides data with the `BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY` option, and specifies `BLOCK_CIPHER_OPTION_STREAM_COMPLETE` on the last block of authenticated data, an authentication tag will be produced, but there will be no resultant `cipherText` or `plainText`. This is known as a Galois Message Authentication Code (GMAC).

GCM/GMAC Software Abstraction Block Diagram



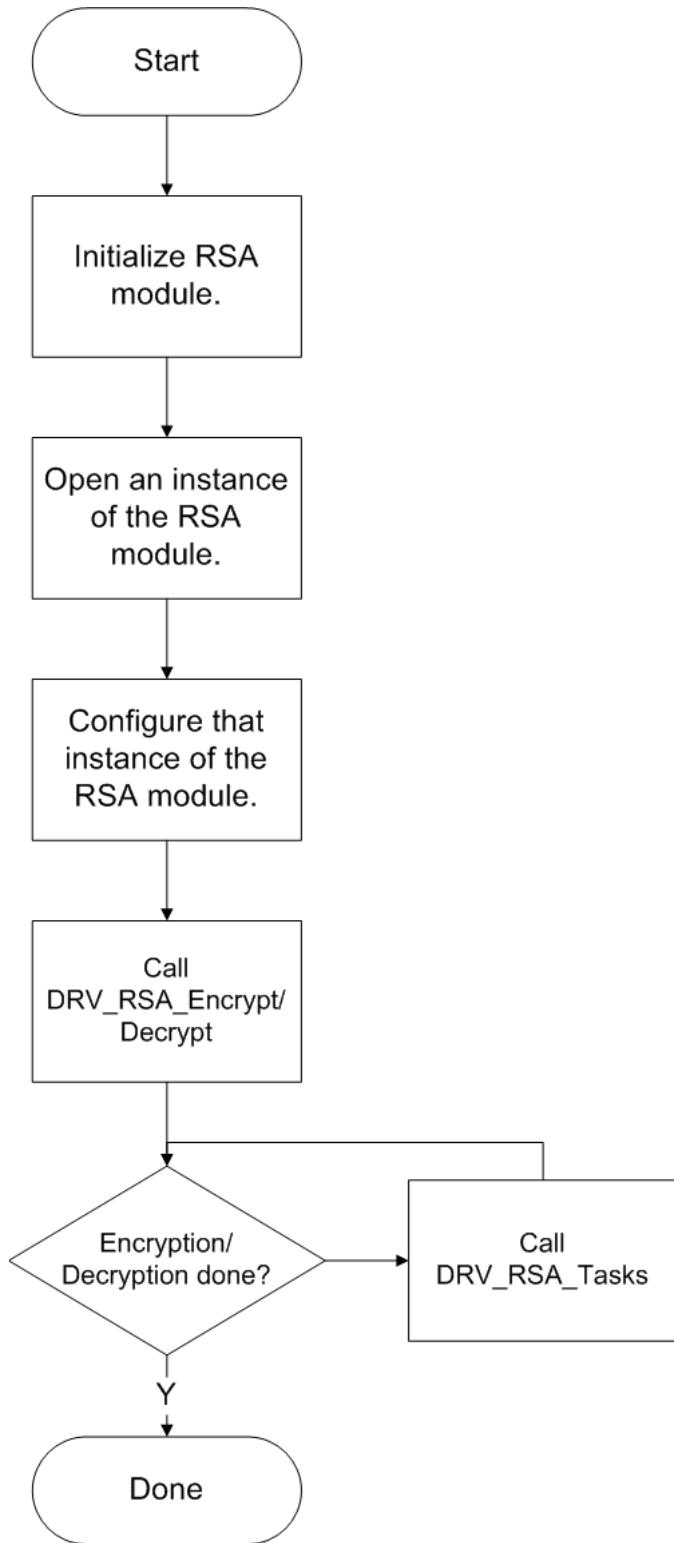
ARCFOUR

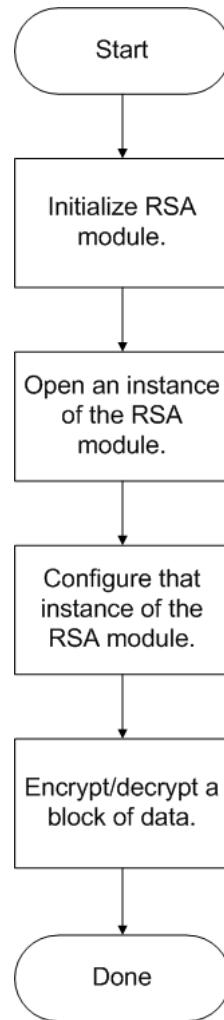
ARCFOUR has a relatively straightforward usage model. The user will use the ARCFOUR key to create an "S-Box" and then use that S-Box to encrypt or decrypt the message.

ARCFOUR Module Software Abstraction Block Diagram**RSA**

RSA has two basic usage models- blocking and non-blocking. In the blocking usage model, the encrypt/decrypt functions will block until the entire RSA encryption or decryption is complete. In some applications this can take an unacceptable amount of time, so a non-blocking mode is also available. This mode will require the user to call the DRV_RSA_Tasks function between calls of the DRV_RSA_Encrypt/DRV_RSA_Decrypt functions until the operation is complete. Note the the dsPIC-only implementation of the RSA module only supports blocking mode at this time, but the execution time of the algorithm is much lower than the non-dsPIC implementation because of use of the DSP instructions available on that device.

RSA Module Software Abstraction Block Diagram (Non-blocking)

**RSA Module Software Abstraction Block Diagram (Blocking)**



1.4.2 Library Overview

Provides an overview of the crypto library.

Description

The library interface routines are divided into various sub-sections, each of sub-section addresses one of the blocks or the overall operation of the crypto module.

Library Interface Section	Description
Block Cipher Modes	Describes the API used by the general block cipher modes of operation module.
AES	Describes the API used by the AES module.
TDES	Describes the API used by the TDES module.
XTEA	Describes the API used by the XTEA module.
ARCFOUR	Describes the API used by the ARCFOUR module.
RSA	Describes the API used by the RSA module.

The block cipher modes of operation are designed to be used with the AES, TDES, and XTEA modules. These block cipher modules do not provide a complete model of security without a mode of operation.

The AES, TDES, and RSA modules are implemented using mixed C and assembly code. This can limit the architectures that they are available on. The AES and TDES modules are implemented for the PIC24 architecture. Note that since the instructions used by the PIC24 architecture are a subset of the instruction sets of other 16-bit architectures, the AES and TDES modules can be used with other 16-bit architectures as well.

The RSA module has two implementations. The first implementation is for the dsPIC architecture only. This implementation makes use of DSP instructions that are only available on this platform. This greatly improves the execution time. However, this implementation is only available in a blocking mode. The other implementation of RSA works on all 16- and 32-bit architectures (including dsPIC) and is available in blocking and non-blocking mode, but the execution time is greater than the dsPIC-only implementation.

1.4.3 How the Library Works

Describes how the library works.

Description

Describes how the library works.

1.4.3.1 Block Ciphers

Describes how the block ciphers work, and how to use them with the block cipher modes of operation.

Description

Describes how the block ciphers work, and how to use them with the block cipher modes of operation.

1.4.3.1.1 Modes of Operation

Describes how the block cipher modes of operation work with each block cipher.

Description

General Functionality

Each mode of operation in the block cipher mode module is used with a specific block cipher module (e.g. AES). Before using the block cipher mode, the user must initialize the block cipher module (if necessary). The user must then use the block cipher's parameters and functions to initialize a block cipher mode context that will be used for the encryption/decryption. To do this, the user will initialize several parameters for the block cipher module:

- Function pointers to the encrypt/decrypt functions for their block cipher. These follow a standard prototype defined in `block_cipher_modes.h` (encrypt prototype, decrypt prototype). The AES, TDES, and XTEA modules have encrypt/decrypt functions implemented in this format, but if you use a custom cipher module you may need to create a shim layer to allow your functions to be called with the standard prototypes.
- A handle that can be passed to the encrypt/decrypt functions to uniquely identify which resources the function should use (if necessary). If no handle is required for your block cipher you can pass in `NULL` for this parameter.
- The block size of the block cipher you are using. The AES, TDES, and XTEA modules included with this cryptographic library define macros that indicate their block size (`AES_BLOCK_SIZE`, `TDES_BLOCK_SIZE`, `XTEA_BLOCK_SIZE`).
- Any initialization data needed by the mode you are using.

ECB

Using the ECB mode of operation is essentially the same as not using a mode of operation. This mode will encrypt blocks of data individually, without providing feedback from previous encryptions. **This mode does not provide sufficient security for use with cryptographic operations.** The only advantage that this mode will provide over the raw block cipher encrypt/decrypt functions is that it will manage encryption/decryption of multiple blocks, cache data to be encrypted/decrypted if there is not enough to comprise a full block, and add padding at the end of a plain text based on

user-specified options.

CBC

The Cipher-block Chaining (CBC) mode of operation uses an initialization vector and information from previous block encryptions to provide additional security.

Before the first encryption, the initialization vector is exclusive or'd (xor'd) with the first block of plaintext. After each encryption, the resulting block of ciphertext is xor'd with the next block of plaintext being encrypted.

When decrypting this message, the IV is xor'd with the first block of decrypted ciphertext to recover the first block of plaintext, the first block of ciphertext is xor'd with the second block of decrypted ciphertext, and so on.

CFB

Like the CBC mode, the Cipher Feedback (CFB) mode of operation uses an initialization vector and propagates information from en/decryptions to subsequent en/decryptions.

In CFB, the initialization vector is encrypted first, then the resulting value is xor'd with the first block of the plaintext to produce the first block of ciphertext. The first ciphertext is then encrypted, the resulting value is xor'd with the second block of plaintext to produce the second block of ciphertext, and so on.

When decrypting, the IV is encrypted again. The resulting value is xor'd with the ciphertext to produce the plaintext, and then the ciphertext is encrypted and xor'd with the next block of ciphertext to produce the second block of plaintext. This process continues until the entire message has been decrypted.

OFB

The Output Feedback (OFB) mode is the same as the CFB mode, except the data being encrypted for the subsequent encryptions is simply the result of the previous encryption instead of the result of the previous encryption xor'd with the plaintext. Note that the result of the encryption is still xor'd with the plaintext to produce the ciphertext; the value is just propagated to the next block encryption before this happens.

Since you don't need to have the plaintext before determining the encrypted values to xor with it, you can pre-generate a keystream for OFB as soon as you get the Initialization Vector and Key, and then use it to encrypt the plaintext when it becomes available. Also, since you can simply xor your keystream with a non-specific amount of plaintext, OFB is effectively a stream cipher, not a block cipher (thought you will still use the block cipher to generate the keystream).

CTR

The Counter (CTR) mode encrypts blocks that contain a counter to generate a keystream. This keystream is then xor'd with the plaintext to produce the ciphertext.

Usually the counter blocks are combined with an Initialization Vector (a security nonce) to provide additional security. In most cases the counter simply is incremented after each block is encrypted/decrypted, but any operation could be applied to the counter as long as the values of the counter didn't repeat frequently. CTR mode combines the advantages of ECB (blocks are encrypted/decrypted without need for information from previous operations, which allows encryptions to be run in parallel) with the advantages of OFB (keystreams can be generated before all of the plaintext is available).

GCM

The Galois/Counter Mode (GCM) is essentially the same as the counter mode for purposes of encryption and decryption. The difference is that GCM will also provide authentication functionality. GCM will use an initialization vector to generate an initial counter. That counter will be used with CTR-mode encryption to produce a ciphertext. The GCM will apply a hashing function to the ciphertext, a user-specified amount of non-encrypted data, and some padding data to produce an output. This hashed value will then be encrypted with the initial counter to produce an authentication tag. See the Abstraction Model topic for more information on how the authentication tag is constructed.

GCM provides several requirements and methods for constructing an initialization vector. In practice, the easiest way to create an acceptable Initialization Vector is to pass a 96-bit random number generated by an approved random bit generator with a sufficient security strength into the `BLOCK_CIPHER_GCM_Initialize` function. See section 8.2 in the GCM specification (NIST SP-800-32D) for more information.

1.4.3.1.2 AES

Describes how the AES module works.

Description

The AES module defines DRV_AES_Initialize/DRV_AES_Deinitialize functions to initialize and deinitialize the module, and DRV_AES_Open/DRV_AES_Close functions to control assignment of drive handles. These functions are intended to provide compatibility with hardware AES modules; if a hardware AES driver is used, these functions will initialize it and assign an instance of the hardware (if multiple instances are available) to the user for the AES operation they are attempting to perform. For pure software implementations, the software driver defines default values for DRV_AES_HANDLE and DRV_AES_INDEX that will be used in all cases.

The AES module should be used with a block cipher mode of operation (see the block cipher modes of operation section for more information). For AES, the block cipher mode module's BLOCK_CIPHER_[mode]_Initialize functions should be initialized with the AES_Encrypt function, the AES_Decrypt function, and the AES_BLOCK_SIZE block size macro. If an initialization vector or nonce/counter is required by the block cipher mode being used, it should be 16 bytes long (one block length).

When using the AES module, the user must first use the AES_RoundKeysCreate function to generate a series of round keys from the 128-, 192- or 256-bit AES key. A pointer to the AES_ROUND_KEYS_128_BIT, AES_ROUND_KEYS_192_BIT, or AES_ROUND_KEYS_256_BIT structure containing these round keys is passed into the block cipher mode module's encrypt/decrypt functions (or to the AES_Encrypt/AES_Decrypt function if a block cipher mode of operation is not being used).

1.4.3.1.3 TDES

Describes how the TDES module works.

Description

The TDES module provides a software-only implementation. As TDES is maintained only until AES can be fully adopted, it is unlikely that any hardware TDES modules will become available, so TDES does not include any initialize/deinitialize or open/close functionality.

The TDES module should be used with a block cipher mode of operation (see the block cipher modes of operation section for more information). For TDES, the block cipher mode module's BLOCK_CIPHER_[mode]_Initialize functions should be initialized with the TDES_Encrypt function, the TDES_Decrypt function, and the TDES_BLOCK_SIZE block size macro. If an initialization vector or nonce/counter is required by the block cipher mode being used, it should be 8 bytes long (one block length).

TDES uses up to 3 64-bit DES keys, depending on the keyring option being used. In keyring option 1, all three keys will be distinct. This provides the most security. In keyring option 2, the first and third key are the same. This provides more security than the DES algorithm that TDES is based on. Keyring option 3 uses the same key three times. It is functionally equivalent to DES, and is provided for backwards compatibility; it should not be used in new applications. In all cases, the three keys should be concatenated into a single 192-bit array.

When using the TDES module, the user must first use the TDES_RoundKeysCreate function to generate a series of round keys from the 192-bit TDES key. A pointer to the TDES_ROUND_KEYS structure containing these round keys is passed into the block cipher mode module's encrypt/decrypt functions (or to the TDES_Encrypt/TDES_Decrypt function if a block cipher mode of operation is not being used).

1.4.3.1.4 XTEA

Describes how the XTEA module works.

Description

The XTEA module should be used with a block cipher mode of operation (see the block cipher modes of operation section

for more information). For XTEA, the block cipher mode module's BLOCK_CIPHER_[mode]_Initialize functions should be initialized with the XTEA_Encrypt function, the XTEA_Decrypt function, and the XTEA_BLOCK_SIZE block size macro. If an initialization vector or nonce/counter is required by the block cipher mode being used, it should be 8 bytes long (one block length).

1.4.3.2 ARCFour

Describes how the ARCFour module works.

Description

Encrypting or decrypting a message using the ARCFour is essentially a two-step process. First, the user will create an S-Box and initialize a "context" for the ARCFour module that will contain a reference to the S-Box and state information that the ARCFour module will use to encrypt or decrypt the message. Then, the user will pass the data to be encrypted and decrypted to the ARCFour module. The module will encrypt/decrypt the data in place.

1.4.3.3 RSA

Describes how the RSA module works.

Description

The RSA module defines DRV_RSA_Initialize/DRV_RSA_Deinitialize functions to initialize and deinitialize the module, and DRV_RSA_Open/DRV_RSA_Close functions to control assignment of drive handles. These functions are intended to provide compatibility with hardware RSA modules; if a hardware RSA/Modular Exponentiation driver is used, these functions will initialize it and assign an instance of the hardware (if multiple instances are available) to the user for the RSA operation they are attempting to perform. For pure software implementations, the software driver defines default values for DRV_RSA_HANDLE and DRV_RSA_INDEX that will be used in all cases.

The RSA module can be opened with several intent options. DRV_IO_INTENT_BLOCKING and DRV_IO_INTENT_NONBLOCKING are used to select whether the module operates in a blocking or non-blocking mode. In the current implementation, the only client mode supported is DRV_IO_INTENT_EXCLUSIVE, which allows the module to support one client at a time.

The RSA module currently supports two implementations. The dsPIC-only implementation allows the user to use DSP-specific instructions to increase performance, but only operates in blocking mode. The other mode will function in blocking and non-blocking modes and will run on 16-bit architectures, but has a longer execution time than the dsPIC-only implementation.

Both implementations require the user to provide working buffers in the configuration function. These are referred to as the xBuffer and yBuffer in the DRV_RSA_Configure function. For the dsPIC implementation, these buffers must be declared in the dsPIC's x-memory and y-memory respectively, using the attributes, "`__attribute__ ((space(xmemory)))`" and "`__attribute__ ((space(ymemory)))`". The xMemory buffer must be 64-byte aligned, and the yMemory buffer must be 4-byte aligned, as well. The xBuffer should be twice as large as the largest supported key length in your application and the yBuffer should be three times as large as the key length. In the other implementation, the buffers should be aligned to the word size of the processor, and both should be twice as large as the largest supported key length.

Parameter	xBuffer (dsPIC)	yBuffer (dsPIC)	xBuffer (other)	ybuffer (other)
Size (multiple of maximum key length supported)	2	3	2	2
Memory	x-memory	y-memory	RAM	RAM
Alignment (byte)	64	2	4	4

The RSA module also requires the user to provide a pointer to a random number generator function for use when padding the messages. This function must conform to the prototype described by the DRV_RSA_RandomGet function.

Once the user has opened and configured their module, they can Encrypt and Decrypt blocks of data. Encryption uses the DRV_RSA_Encrypt function, which performs a modular exponentiation on the data using a public key passed in in a DRV_RSA_PUBLIC_KEY structure. Decryption uses the DRV_RSA_Decrypt function, which uses modular exponentiation and the Chinese Remainder Theorem on the cipherText using a private key passed in in a DRV_RSA_PRIVATE_KEY_CRT structure. All of the key parameters in the public key structure and the private key structure are little-endian.

In the blocking mode, the encrypt and decrypt functions will block until the encryption and decryption are complete. In the non-blocking mode, the encrypt and decrypt functions will return a DRV_RSA_STATUS value. If this status value indicates that the encryption/decryption operation is still in progress the user must then alternate calling the DRV_RSA_ClientStatus function and the DRV_RSA_Tasks function until the ClientStatus function returns DRV_RSA_STATUS_READY or one of the specified error conditions.

1.5 Configuring the Library

Describes the crypto library configuration.

Macros

Name	Description
CRYPTO_CONFIG_AES_KEY_128_ENABLE	Define this macro to only use 128-bit key lengths
CRYPTO_CONFIG_AES_KEY_192_ENABLE	Define this macro to only use 192-bit key lengths
CRYPTO_CONFIG_AES_KEY_256_ENABLE	Define this macro to use 256-bit key lengths. Enabling this will actually enable CRYPTO_CONFIG_AES_KEY_DYNAMIC
CRYPTO_CONFIG_AES_KEY_DYNAMIC_ENABLE	Define this macro to dynamically determine key length at runtime
CRYPTO_CONFIG_BLOCK_MAX_SIZE	Block Cipher Configuration options (AES, TDES, XTEA)

Description

The configuration of the crypto library is based on the file `crypto_config.h`. This file (or the definitions it describes) must be included in a header named `system_config.h`, which will be included directly by the library source files.

The `crypto_config.h` header file contains the configuration selection for this cryptographic library, including configuration for the AES module and general configuration for the block cipher mode module. Based on the selections made, the crypto library will support or not support selected features. These configuration settings will apply to all instances of the crypto library.

This header can be placed anywhere; however, the path of this header needs to be present in the include search path for a successful build.

1.5.1 CRYPTO_CONFIG_AES_KEY_128_ENABLE Macro

File

`crypto_config_template.h`

Syntax

```
#define CRYPTO_CONFIG_AES_KEY_128_ENABLE
```

Description

Define this macro to only use 128-bit key lengths

1.5.2 CRYPTO_CONFIG_AES_KEY_192_ENABLE Macro

File

`crypto_config_template.h`

Syntax

```
#define CRYPTO_CONFIG_AES_KEY_192_ENABLE
```

Description

Define this macro to only use 192-bit key lengths

1.5.3 CRYPTO_CONFIG_AES_KEY_256_ENABLE Macro

File

crypto_config_template.h

Syntax

```
#define CRYPTO_CONFIG_AES_KEY_256_ENABLE
```

Description

Define this macro to use 256-bit key lengths. Enabling this will actually enable CRYPTO_CONFIG_AES_KEY_DYNAMIC

1.5.4 CRYPTO_CONFIG_AES_KEY_DYNAMIC_ENABLE Macro

File

crypto_config_template.h

Syntax

```
#define CRYPTO_CONFIG_AES_KEY_DYNAMIC_ENABLE
```

Description

Define this macro to dynamically determine key length at runtime

1.5.5 CRYPTO_CONFIG_BLOCK_MAX_SIZE Macro

File

crypto_config_template.h

Syntax

```
#define CRYPTO_CONFIG_BLOCK_MAX_SIZE 16ul
```

Description

Block Cipher Configuration options (AES, TDES, XTEA)

Defines the largest block size used by the ciphers you are using with the block cipher modes of operation

1.6 Building the Library

Describes source files used by the crypto library.

Description

This section lists the files that are available in the \src of the crypto library. It lists which files need to be included in the build based on either a hardware feature present on the board or configuration option selected by the system.

1.6.1 Block Cipher Modes

This section describes the source files that must be included when building the block cipher modes of operation.

Description

This section describes the source files that must be included when building the AES module.

These files are located in the `crypto/src/block_cipher_modes` directory.

File	Description	Conditions
<code>block_cipher_mode_private.c</code>	Contains general purpose non-public functions.	Must be included.
<code>block_cipher_mode_cbc.c</code>	Contains functions used for the CBC mode of operation.	Must be included when using CBC mode.
<code>block_cipher_mode_cfb.c</code>	Contains functions used for the CFB mode of operation.	Must be included when using CFB mode.
<code>block_cipher_mode_ofb.c</code>	Contains functions used for the OFB mode of operation.	Must be included when using OFB mode.
<code>block_cipher_mode_ctr.c</code>	Contains functions used for the CTR mode of operation.	Must be included when using CTR mode.
<code>block_cipher_mode_ecb.c</code>	Contains functions used for the ECB mode of operation.	Must be included when using ECB mode.
<code>block_cipher_mode_gcm.c</code>	Contains functions used for the GCM mode of operation.	Must be included when using GCM mode.

1.6.2 AES

This section describes the source files that must be included when building the AES module.

Description

This section describes the source files that must be included when building the AES module.

16-bit PICs

These files are located in the `crypto/src/aes/16bit` directory.

File	Description	Conditions
<code>aes.c</code>	Contains general purpose AES functions.	Must be included.
<code>aes_encrypt_16bit.s</code>	Contains functions for encrypting plainText.	Must be included when encrypting data.

aes_decrypt_16bit.s	Contains functions for decrypting cipherText.	Must be included when decrypting data.
aes_128bit_16bit.s	Contains round key generation functions for 128-bit AES keys.	Must be included when the AES_KEY_DYNAMIC or AES_KEY_128 configurations options are selected.
aes_192bit_16bit.s	Contains round key generation functions for 192-bit AES keys.	Must be included when the AES_KEY_DYNAMIC or AES_KEY_192 configurations options are selected.
aes_256bit_16bit.s	Contains round key generation functions for 256-bit AES keys.	Must be included when the AES_KEY_DYNAMIC or AES_KEY_256 configurations options are selected.

1.6.3 TDES

This section describes the source files that must be included when building the TDES module.

Description

This section describes the source files that must be included when building the TDES module.

16-bit PICs

These files are located in the `crypto/src/tdes/16bit` directory.

File	Description	Conditions
tdes_16bit.s	Uses the DES functions to perform TDES encryption/decryption.	Must be included.
des_16bit.s	Performs DES encryption/decryption.	Must be included.

1.6.4 XTEA

This section describes the source files that must be included when building the XTEA module.

Description

This section describes the source files that must be included when building the XTEA module.

These files are located in the `crypto/src/xtea` directory.

File	Description	Conditions
xtea.c	Contains functionality for the XTEA module.	Must be included.

1.6.5 ARCFOUR

This section describes the source files that must be included when building the ARCFOUR module.

Description

This section describes the source files that must be included when building the ARCFOUR module.

These files are located in the `crypto/src/arcfour` directory.

File	Description	Conditions
arcfour.c	Contains functionality for the ARCFOUR module.	Must be included.

1.6.6 RSA

This section describes the source files that must be included when building the RSA module.

Description

This section describes the source files that must be included when building the RSA module.

dsPIC-Only Implementation

These files are located in the `crypto/src/rsa/dspic` directory.

File	Description
<code>rsa_dspic_abstraction.c</code>	Provides a shim layer between the common RSA API and the dsPIC-only module's API.
<code>math.s</code>	Provides math routines for this implementation.
<code>math_mod_inv.s</code>	Provides math routines to compute a modular inverse.
<code>mont.s</code>	Provides routines to perform Montgomery operations to support modular exponentiation and modular arithmetic.
<code>rsa_crt.s</code>	Provides routines for Chinese Remainder Theorem (CRT) operations.
<code>rsa_enc_dec.s</code>	Provides routines for encryption and decryption.

Other Implementations

These files are located in the `crypto/src/rsa/other` directory.

File	Description
<code>rsa.c</code>	Contains all RSA functionality.

The "Other" implementation of the RSA module also depends on several math routines for big integers. The big integer math library (`bigint`) is distributed with this crypto library. The following source files must be included in your project when using the RSA module:

16-bit

The default installation directory for these files is `libraries/bigint/src/16bit`.

File	Description
<code>bigint_16bit.c</code>	Contains interface functions for bigint math.
<code>bigint_helper_16bit.S</code>	Contains helper functions for the bigint library.

1.7 Library Interface

This section describes the Application Programming Interface (API) functions of the crypto module.

Refer to each section for a detailed description.

Modules

Name	Description
AES	This section describes the Application Programming Interface (API) functions of the AES module.
TDES	This section describes the Application Programming Interface (API) functions of the TDES module.
XTEA	This section describes the Application Programming Interface (API) functions of the XTEA module.
ARCFOUR	This section describes the Application Programming Interface (API) functions of the ARCFOUR module.
RSA	This section describes the Application Programming Interface (API) functions of the RSA module.

Description

This section describes the Application Programming Interface (API) functions of the crypto module.

Refer to each section for a detailed description.

1.7.1 Block Cipher Modes

Describes the functions and structures used to interface to this module.

Modules

Name	Description
General Functionality	Describes general functionality used by the block cipher mode module.
ECB	Describes functionality specific to the Electronic Codebook (ECB) block cipher mode of operation.
CBC	Describes functionality specific to the Cipher-Block Chaining (CBC) block cipher mode of operation.
CFB	Describes functionality specific to the Cipher Feedback (CFB) block cipher mode of operation.
OFB	Describes functionality specific to the Output Feedback (OFB) block cipher mode of operation.
CTR	Describes functionality specific to the Counter (CTR) block cipher mode of operation.
GCM	Describes functionality specific to the Galois/Counter Mode (GCM) block cipher mode of operation.

Description

Describes the functions and structures used to interface to this module.

1.7.1.1 General Functionality

Describes general functionality used by the block cipher mode module.

Enumerations

Name	Description
BLOCK_CIPHER_ERRORS	Enumeration defining potential errors that can occur when using a block cipher mode of operation. Modes that do not use keystreams will not generate errors.
BLOCK_CIPHER_MODES	Enumeration defining available block cipher modes of operation

Types

Name	Description
BLOCK_CIPHER_FunctionEncrypt	Function pointer for a block cipher's encryption function. When using the block cipher modes of operation module, you will configure it to use the encrypt function of the block cipher module that you are using with a pointer to that block cipher's encrypt function. None
BLOCK_CIPHER_FunctionDecrypt	Function pointer for a block cipher's decryption function. When using the block cipher modes of operation module, you will configure it to use the decrypt function of the block cipher module that you are using with a pointer to that block cipher's encrypt function. None

Description

Describes general functionality used by the block cipher mode module.

1.7.1.1.1 Options

Describes general options that can be selected when encrypting/decrypting a message.

Macros

Name	Description
BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY	This option is used to pass data that will be authenticated but not encrypted into an authenticating block cipher mode function.
BLOCK_CIPHER_OPTION_STREAM_START	This should be passed when a new stream is starting.
BLOCK_CIPHER_OPTION_STREAM_CONTINUE	The stream is still in progress.
BLOCK_CIPHER_OPTION_STREAM_COMPLETE	The stream is complete. Padding will be applied if required.
BLOCK_CIPHER_OPTION_OPTIONS_DEFAULT	A definition to specify the default set of options.
BLOCK_CIPHER_OPTION_PAD_MASK	Mask to determine the padding option that is selected.
BLOCK_CIPHER_OPTION_PAD_NONE	Pad with whatever data is already in the RAM. This flag is normally set only for the last block of data.
BLOCK_CIPHER_OPTION_PAD_NULLS	Pad with 0x00 bytes if the current and previous data lengths do not end on a block boundary (multiple of 16 bytes). This flag is normally set only for the last block of data.
BLOCK_CIPHER_OPTION_PAD_8000	Pad with 0x80 followed by 0x00 bytes (a 1 bit followed by several 0 bits) if the current and previous data lengths do not end on a block boundary (multiple of 16 bytes). This flag is normally set only for the last block of data.
BLOCK_CIPHER_OPTION_PAD_NUMBER	Pad with three 0x03's, four 0x04's, five 0x05's, six 0x06's, etc. set by the number of padding bytes needed if the current and previous data lengths do not end on a block boundary (multiple of 16 bytes). This flag is normally set only for the last block of data.

BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_ALIGNED	The plain text pointer is pointing to data that is aligned to the target machine's word size (16-bit aligned for PIC24/dsPIC30/dsPIC33, and 8-bit aligned for PIC18). Enabling this feature may improve throughput.
BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED	The cipher text pointer is pointing to data that is aligned to the target machine's word size (16-bit aligned for PIC24/dsPIC30/dsPIC33, and 8-bit aligned for PIC18). Enabling this feature may improve throughput.
BLOCK_CIPHER_OPTION_USE_CFB1	Calculate the key stream for CFB1 mode
BLOCK_CIPHER_OPTION_USE_CFB8	Calculate the key stream for CFB8 mode
BLOCK_CIPHER_OPTION_USE_CFB_BLOCK_SIZE	Calculate the key stream for CFB(block size) mode
BLOCK_CIPHER_OPTION_CTR_SIZE_MASK	Mask to determine the size of the counter in bytes.
BLOCK_CIPHER_OPTION_CTR_32BIT	Treat the counter as a 32-bit counter. Leave the remaining section of the counter unchanged
BLOCK_CIPHER_OPTION_CTR_64BIT	Treat the counter as a 64-bit counter. Leave the remaining section of the counter unchanged
BLOCK_CIPHER_OPTION_CTR_128BIT	Treat the counter as a full 128-bit counter. This is the default option.

Module

General Functionality

Description

Describes general options that can be selected when encrypting/decrypting a message. Some of these options may not be necessary in certain modes of operation (for example, padding is not necessary when using OFB, which operates as a stream cipher). Note that the CTR and CFB modes have additional options that apply only to those modes.

1.7.1.1.1.1 BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY Macro**File**

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY
```

Description

This option is used to pass data that will be authenticated but not encrypted into an authenticating block cipher mode function.

1.7.1.1.1.2 BLOCK_CIPHER_OPTION_STREAM_START Macro**File**

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_STREAM_START
```

Description

This should be passed when a new stream is starting

1.7.1.1.1.3 BLOCK_CIPHER_OPTION_STREAM_CONTINUE Macro**File**

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_STREAM_CONTINUE
```

Description

The stream is still in progress.

1.7.1.1.4 BLOCK_CIPHER_OPTION_STREAM_COMPLETE Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_STREAM_COMPLETE
```

Description

The stream is complete. Padding will be applied if required.

1.7.1.1.5 BLOCK_CIPHER_OPTION_OPTIONS_DEFAULT Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_OPTIONS_DEFAULT
```

Description

A definition to specify the default set of options.

1.7.1.1.6 BLOCK_CIPHER_OPTION_PAD_MASK Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_PAD_MASK
```

Description

Mask to determine the padding option that is selected.

1.7.1.1.7 BLOCK_CIPHER_OPTION_PAD_NONE Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_PAD_NONE
```

Description

Pad with whatever data is already in the RAM. This flag is normally set only for the last block of data.

1.7.1.1.8 BLOCK_CIPHER_OPTION_PAD_NULLS Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_PAD_NULLS
```

Description

Pad with 0x00 bytes if the current and previous data lengths do not end on a block boundary (multiple of 16 bytes). This flag is normally set only for the last block of data.

1.7.1.1.9 **BLOCK_CIPHER_OPTION_PAD_8000** Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_PAD_8000
```

Description

Pad with 0x80 followed by 0x00 bytes (a 1 bit followed by several 0 bits) if the current and previous data lengths do not end on a block boundary (multiple of 16 bytes). This flag is normally set only for the last block of data.

1.7.1.1.10 **BLOCK_CIPHER_OPTION_PAD_NUMBER** Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_PAD_NUMBER
```

Description

Pad with three 0x03's, four 0x04's, five 0x05's, six 0x06's, etc. set by the number of padding bytes needed if the current and previous data lengths do not end on a block boundary (multiple of 16 bytes). This flag is normally set only for the last block of data.

1.7.1.1.11 **BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_ALIGNED** Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_ALIGNED
```

Description

The plain text pointer is pointing to data that is aligned to the target machine's word size (16-bit aligned for PIC24/dsPIC30/dsPIC33, and 8-bit aligned for PIC18). Enabling this feature may improve throughput.

1.7.1.1.12 **BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED** Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED
```

Description

The cipher text pointer is pointing to data that is aligned to the target machine's word size (16-bit aligned for PIC24/dsPIC30/dsPIC33, and 8-bit aligned for PIC18). Enabling this feature may improve throughput.

1.7.1.1.1.13 BLOCK_CIPHER_OPTION_USE_CFB1 Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_USE_CFB1
```

Description

Calculate the key stream for CFB1 mode

1.7.1.1.1.14 BLOCK_CIPHER_OPTION_USE_CFB8 Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_USE_CFB8
```

Description

Calculate the key stream for CFB8 mode

1.7.1.1.1.15 BLOCK_CIPHER_OPTION_USE_CFB_BLOCK_SIZE Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_USE_CFB_BLOCK_SIZE
```

Description

Calculate the key stream for CFB(block size) mode

1.7.1.1.1.16 BLOCK_CIPHER_OPTION_CTR_SIZE_MASK Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_CTR_SIZE_MASK
```

Description

Mask to determine the size of the counter in bytes.

1.7.1.1.1.17 BLOCK_CIPHER_OPTION_CTR_32BIT Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_CTR_32BIT
```

Description

Treat the counter as a 32-bit counter. Leave the remaining section of the counter unchanged

1.7.1.1.1.18 BLOCK_CIPHER_OPTION_CTR_64BIT Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_CTR_64BIT
```

Description

Treat the counter as a 64-bit counter. Leave the remaining section of the counter unchanged

1.7.1.1.1.19 BLOCK_CIPHER_OPTION_CTR_128BIT Macro

File

block_cipher_modes.h

Syntax

```
#define BLOCK_CIPHER_OPTION_CTR_128BIT
```

Description

Treat the counter as a full 128-bit counter. This is the default option.

1.7.1.1.2 BLOCK_CIPHER_ERRORS Enumeration

File

block_cipher_modes.h

Syntax

```
typedef enum {
    BLOCK_CIPHER_ERROR_NONE = (0x00000000u),
    BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE,
    BLOCK_CIPHER_ERROR_CTR_COUNTER_EXPIRED,
    BLOCK_CIPHER_ERROR_INVALID_AUTHENTICATION
} BLOCK_CIPHER_ERRORS;
```

Members

Members	Description
BLOCK_CIPHER_ERROR_NONE = (0x00000000u)	No errors.
BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE	The calling function has requested that more bits be added to the key stream then are available in the buffer allotted for the key stream. Since there was not enough room to complete the request, the request was not processed.
BLOCK_CIPHER_ERROR_CTR_COUNTER_EXPIRED	The requesting call has caused the counter number to run out of unique combinations. In CTR mode it is not safe to use the same counter value for a given key.
BLOCK_CIPHER_ERROR_INVALID_AUTHENTICATION	Authentication of the specified data failed.

Module

General Functionality

Description

Enumeration defining potential errors that can occur when using a block cipher mode of operation. Modes that do not use keystreams will not generate errors.

1.7.1.1.3 BLOCK_CIPHER_MODES Enumeration

File

block_cipher_modes.h

Syntax

```
typedef enum {
    BLOCK_CIPHER_MODE_ECB = 0,
    BLOCK_CIPHER_MODE_CBC,
    BLOCK_CIPHER_MODE_CFB,
    BLOCK_CIPHER_MODE_OFB,
    BLOCK_CIPHER_MODE_CTR
} BLOCK_CIPHER_MODES;
```

Members

Members	Description
BLOCK_CIPHER_MODE_ECB = 0	Electronic Codebook mode
BLOCK_CIPHER_MODE_CBC	Cipher-block Chaining mode
BLOCK_CIPHER_MODE_CFB	Cipher Feedback mode
BLOCK_CIPHER_MODE_OFB	Output Feedback mode
BLOCK_CIPHER_MODE_CTR	Counter mode

Module

General Functionality

Description

Enumeration defining available block cipher modes of operation

1.7.1.1.4 BLOCK_CIPHER_FunctionEncrypt Type

File

block_cipher_modes.h

Syntax

```
typedef void (* BLOCK_CIPHER_FunctionEncrypt) (DRV_HANDLE handle, void * cipherText, void *
plainText, void * key);
```

Module

General Functionality

Side Effects

None

Returns

None

Description

Function pointer for a block cipher's encryption function. When using the block cipher modes of operation module, you will configure it to use the encrypt function of the block cipher module that you are using with a pointer to that block cipher's encrypt function.

None

Remarks

None

Preconditions

None

Parameters

Parameters	Description
handle	A driver handle. If the encryption module you are using has multiple instances, this handle will be used to differentiate them. For single instance encryption modules (software-only modules) this parameter can be specified as NULL.
cipherText	The resultant cipherText produced by the encryption. The type of pointer used for this parameter will be dependent on the block cipher module you are using.
plainText	The plainText that will be encrypted. The type of pointer used for this parameter will be dependent on the block cipher module you are using.
key	Pointer to the key. The format and length of the key depends on the block cipher module you are using.

Function

```
void BLOCK_CIPHER_FunctionEncrypt (
    DRV_HANDLE handle, void * cipherText,
    void * plainText, void * key)
```

1.7.1.1.5 BLOCK_CIPHER_FunctionDecrypt Type**File**

block_cipher_modes.h

Syntax

```
typedef void (* BLOCK_CIPHER_FunctionDecrypt) (DRV_HANDLE handle, void * plainText, void *
cipherText, void * key);
```

Module

General Functionality

Side Effects

None

Returns

None

Description

Function pointer for a block cipher's decryption function. When using the block cipher modes of operation module, you will configure it to use the decrypt function of the block cipher module that you are using with a pointer to that block cipher's encrypt function.

None

Remarks

None

Preconditions

None

Parameters

Parameters	Description
handle	A driver handle. If the decryption module you are using has multiple instances, this handle will be used to differentiate them. For single instance decryption modules (software-only modules) this parameter can be specified as NULL.
plainText	The resultant plainText that was decrypted. The type of pointer used for this parameter will be dependent on the block cipher module you are using.
cipherText	The cipherText that will be decrypted. The type of pointer used for this parameter will be dependent on the block cipher module you are using.
key	Pointer to the key. The format and length of the key depends on the block cipher module you are using.

Function

```
void BLOCK_CIPHER_FunctionDecrypt (
    DRV_HANDLE handle, void * cipherText,
    void * plainText, void * key)
```

1.7.1.2 ECB

Describes functionality specific to the Electronic Codebook (ECB) block cipher mode of operation.

Functions

	Name	Description
💡	BLOCK_CIPHER_ECB_Initialize	Initializes a ECB context for encryption/decryption.
💡	BLOCK_CIPHER_ECB_Encrypt	Encrypts plain text using electronic codebook mode.
💡	BLOCK_CIPHER_ECB_Decrypt	Decrypts cipher text using cipher-block chaining mode.

Structures

Name	Description
BLOCK_CIPHER_ECB_CONTEXT	Context structure for the electronic codebook operation

Description

Describes functionality specific to the Electronic Codebook (ECB) block cipher mode of operation.

1.7.1.2.1 BLOCK_CIPHER_ECB_CONTEXT Structure

File

block_cipher_mode_ecb.h

Syntax

```
typedef struct {
    uint8_t remainingData[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint32_t blockSize;
    BLOCK_CIPHER_FunctionEncrypt encrypt;
    BLOCK_CIPHER_FunctionDecrypt decrypt;
    uint8_t bytesRemaining;
} BLOCK_CIPHER_ECB_CONTEXT;
```

Members

Members	Description
uint8_t remainingData[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer to store data until more is available if there is not enough to encrypt an entire block.
uint32_t blockSize;	Block size of the cipher algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionEncrypt encrypt;	Encrypt function for the algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionDecrypt decrypt;	Decrypt function for the algorithm being used with the block cipher mode module
uint8_t bytesRemaining;	Number of bytes remaining in the remainingData buffer

Module

ECB

Description

Context structure for the electronic codebook operation

1.7.1.2.2 BLOCK_CIPHER_ECB_Initialize Function

Initializes a ECB context for encryption/decryption.

File

block_cipher_mode_ecb.h

Syntax

```
void BLOCK_CIPHER_ECB_Initialize(BLOCK_CIPHER_ECB_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction, BLOCK_CIPHER_FunctionDecrypt decryptFunction,
uint32_t blockSize);
```

Module

ECB

Returns

None.

Description

Initializes a ECB context for encryption/decryption. The user will specify details about the algorithm being used in ECB mode.

Preconditions

Any required initialization needed by the block cipher algorithm must have been performed.

Example

```
// Initialize the ECB block cipher module for use with AES.
SYS_MODULE_OBJ sysObject;
DRV_HANDLE handle;
BLOCK_CIPHER_ECB_CONTEXT context;

sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}
```

```
// Initialize the block cipher module
BLOCK_CIPHER_ECB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE);
```

Parameters

Parameters	Description
context	The ECB context to initialize.
encryptFunction	Pointer to the encryption function for the block cipher algorithm being used in ECB mode.
decryptFunction	Pointer to the decryption function for the block cipher algorithm being used in ECB mode.
blockSize	The block size of the block cipher algorithm being used in ECB mode.

Function

```
void BLOCK_CIPHER_ECB_Initialize ( BLOCK_CIPHER_ECB_CONTEXT * context,
                                    BLOCK_CIPHER_FunctionEncrypt encryptFunction,
                                    BLOCK_CIPHER_FunctionDecrypt decryptFunction, uint32_t blockSize)
```

1.7.1.2.3 BLOCK_CIPHER_ECB_Encrypt Function

Encrypts plain text using electronic codebook mode.

File

block_cipher_mode_ecb.h

Syntax

```
void BLOCK_CIPHER_ECB_Encrypt(DRV_HANDLE handle, uint8_t * cipherText, uint32_t * numCipherBytes, uint8_t * plainText, uint32_t numPlainBytes, void * key, BLOCK_CIPHER_ECB_CONTEXT * context, uint32_t options);
```

Module

ECB

Returns

None

Description

Encrypts plain text using electronic codebook mode.

Preconditions

The ECB context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

Example

```
// ****
// Encrypt data in ECB mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// ECB mode context
BLOCK_CIPHER_ECB_CONTEXT context;

// Plain text to encrypt
static uint8_t plainText[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d, 0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a, }
```

```

        0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
        0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
        0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};
// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};
// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
// The number of bytes that were encrypted
uint32_t num_bytes_encrypted;

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_ECB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE);

//Encrypt the data
BLOCK_CIPHER_ECB_Encrypt (handle, cipher_text, &num_bytes_encrypted, (void *) plain_text,
sizeof(plain_text), &round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_START);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
cipherText	The cipher text produced by the encryption. This buffer must be a multiple of the block size, even if the plain text buffer size is not. This buffer should always be larger than the plain text buffer.
numCipherBytes	Pointer to a uint32_t; the number of bytes encrypted will be returned in this parameter.
plainText	The plain test to encrypt.
numPlainBytes	The number of plain text bytes that must be encrypted. If the number of plain text bytes encrypted is not evenly divisible by the block size, the remaining bytes will be cached in the ECB context structure until additional data is provided.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.

context	Pointer to a context structure for this encryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	<p>Block cipher encryption options that the user can specify, or'd together. Valid options for this function are</p> <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_PAD_NONE • BLOCK_CIPHER_OPTION_PAD_NULLS • BLOCK_CIPHER_OPTION_PAD_8000 • BLOCK_CIPHER_OPTION_PAD_NUMBER • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE • BLOCK_CIPHER_OPTION_STREAM_COMPLETE • BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED • BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_ALIGNED

Function

```
void BLOCK_CIPHER_ECB_Encrypt (DRV_HANDLE handle, uint8_t * cipherText,
                               uint32_t * numCipherBytes, uint8_t * plainText, uint32_t numPlainBytes,
                               void * key,     BLOCK_CIPHER_ECB_CONTEXT * context, uint32_t options);
```

1.7.1.2.4 BLOCK_CIPHER_ECB_Decrypt Function

Decrypts cipher text using cipher-block chaining mode.

File

block_cipher_mode_ecb.h

Syntax

```
void BLOCK_CIPHER_ECB_Decrypt (DRV_HANDLE handle, uint8_t * plainText, uint32_t * numPlainBytes,
                               uint8_t * cipherText, uint32_t numCipherBytes, void * key,
                               BLOCK_CIPHER_ECB_CONTEXT * context, uint32_t options);
```

Module

ECB

Returns

None

Description

Decrypts cipher text using cipher-block chaining mode.

Preconditions

The ECB context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

Example

```

// ****
// Decrypt data in ECB mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// ECB mode context
BLOCK_CIPHER_ECB_CONTEXT context;

// Cipher text to decrypt
static uint8_t cipher_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9,
0x3d, 0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
                    0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e,
0xb7, 0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
                    0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5,
0xfb, 0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
                    0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad,
0x2b, 0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = { 0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t plain_text[sizeof(cipher_text)];
// The number of bytes that were decrypted
uint32_t num_bytes_decrypted;

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

// Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_ECB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE);

// Decrypt the data
BLOCK_CIPHER_ECB_Decrypt (handle, plain_text, &num_bytes_decrypted, (void *) cipher_text,
sizeof(cipher_text), &round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_START);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
plainText	The plain test produced by the decryption. This buffer must be a multiple of the block cipher's block size, even if the cipher text passed in is not.

numPlainBytes	Pointer to a uint32_t; the number of bytes decrypted will be returned in this parameter.
cipherText	The cipher text that will be decrypted. This buffer must be a multiple of the block size, unless this is the end of the stream (the BLOCK_CIPHER_OPTION_STREAM_COMPLETE option must be set in this case).
numCipherBytes	The number of cipher text bytes to decrypt.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this decryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher encryption options that the user can specify, or'd together. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_COMPLETE • • BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED • • BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_ALIGNED

Function

```
void BLOCK_CIPHER_ECB_Decrypt (DRV_HANDLE handle, uint8_t * plainText,
                               uint32_t * numPlainBytes, uint8_t * cipherText, uint32_t numCipherBytes,
                               void * key,     BLOCK_CIPHER_ECB_CONTEXT * context, uint32_t options)
```

1.7.1.3 CBC

Describes functionality specific to the Cipher-Block Chaining (CBC) block cipher mode of operation.

Functions

	Name	Description
💡	BLOCK_CIPHER_CBC_Initialize	Initializes a CBC context for encryption/decryption.
💡	BLOCK_CIPHER_CBC_Encrypt	Encrypts plain text using cipher-block chaining mode.
💡	BLOCK_CIPHER_CBC_Decrypt	Decrypts cipher text using cipher-block chaining mode.

Structures

Name	Description
BLOCK_CIPHER_CBC_CONTEXT	Context structure for a cipher-block chaining operation

Description

Describes functionality specific to the Cipher-Block Chaining (CBC) block cipher mode of operation.

1.7.1.3.1 BLOCK_CIPHER_CBC_CONTEXT Structure

File

block_cipher_mode_cbc.h

Syntax

```
typedef struct {
    uint8_t initializationVector[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint8_t remainingData[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint32_t blockSize;
    BLOCK_CIPHER_FunctionEncrypt encrypt;
    BLOCK_CIPHER_FunctionDecrypt decrypt;
    uint8_t bytesRemaining;
} BLOCK_CIPHER_CBC_CONTEXT;
```

Members

Members	Description
uint8_t initializationVector[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Initialization vector for the CBC operation
uint8_t remainingData[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer to store data until more is available if there is not enough to encrypt an entire block.
uint32_t blockSize;	Block size of the cipher algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionEncrypt encrypt;	Encrypt function for the algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionDecrypt decrypt;	Decrypt function for the algorithm being used with the block cipher mode module
uint8_t bytesRemaining;	Number of bytes remaining in the remainingData buffer

Module

CBC

Description

Context structure for a cipher-block chaining operation

1.7.1.3.2 BLOCK_CIPHER_CBC_Initialize Function

Initializes a CBC context for encryption/decryption.

File

block_cipher_mode_cbc.h

Syntax

```
void BLOCK_CIPHER_CBC_Initialize(BLOCK_CIPHER_CBC_CONTEXT * context,
                                BLOCK_CIPHER_FunctionEncrypt encryptFunction, BLOCK_CIPHER_FunctionDecrypt decryptFunction,
                                uint32_t blockSize, uint8_t * initializationVector);
```

Module

CBC

Returns

None.

Description

Initializes a CBC context for encryption/decryption. The user will specify details about the algorithm being used in CBC mode.

Preconditions

Any required initialization needed by the block cipher algorithm must have been performed.

Example

```

// Initialize the CBC block cipher module for use with AES.
SYS_MODULE_OBJ sysObject;
DRV_HANDLE handle;
BLOCK_CIPHER_CBC_CONTEXT context;
// Initialization vector for CBC mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

// Initialize the block cipher module
BLOCK_CIPHER_CBC_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector);

```

Parameters

Parameters	Description
context	The CBC context to initialize.
encryptFunction	Pointer to the encryption function for the block cipher algorithm being used in CBC mode.
decryptFunction	Pointer to the decryption function for the block cipher algorithm being used in CBC mode.
blockSize	The block size of the block cipher algorithm being used in CBC mode.
initializationVector	The initialization vector for this operation. The length of this vector must be equal to the block size of your block cipher.

Function

```

void BLOCK_CIPHER_CBC_Initialize ( BLOCK_CIPHER_CBC_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction,
BLOCK_CIPHER_FunctionDecrypt decryptFunction, uint32_t blockSize,
uint8_t * initializationVector)

```

1.7.1.3.3 BLOCK_CIPHER_CBC_Encrypt Function

Encrypts plain text using cipher-block chaining mode.

File

block_cipher_mode_cbc.h

Syntax

```

void BLOCK_CIPHER_CBC_Encrypt(DRV_HANDLE handle, uint8_t * cipherText, uint32_t *
numCipherBytes, uint8_t * plainText, uint32_t numPlainBytes, void * key,
BLOCK_CIPHER_CBC_CONTEXT * context, uint32_t options);

```

Module

CBC

Returns

None

Description

Encrypts plain text using cipher-block chaining mode.

Preconditions

The CBC context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

Example

```

// ****
// Encrypt data in CBC mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// CBC mode context
BLOCK_CIPHER_CBC_CONTEXT context;

// Initialization vector for CBC mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Plain text to encrypt
static uint8_t plain_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
// The number of bytes that were encrypted
uint32_t num_bytes_encrypted;

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

// Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_CBC_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector);

// Encrypt the data
BLOCK_CIPHER_CBC_Encrypt (handle, cipher_text, &num_bytes_encrypted, (void *) plain_text,
sizeof(plain_text), &round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_START);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
cipherText	The cipher text produced by the encryption. This buffer must be a multiple of the block size, even if the plain text buffer size is not. This buffer should always be larger than the plain text buffer.
numCipherBytes	Pointer to a uint32_t; the number of bytes encrypted will be returned in this parameter.
plainText	The plain test to encrypt.
numPlainBytes	The number of plain text bytes that must be encrypted. If the number of plain text bytes encrypted is not evenly divisible by the block size, the remaining bytes will be cached in the CBC context structure until additional data is provided.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this encryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher encryption options that the user can specify, or'd together. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_PAD_NONE • BLOCK_CIPHER_OPTION_PAD_NULLS • BLOCK_CIPHER_OPTION_PAD_8000 • BLOCK_CIPHER_OPTION_PAD_NUMBER • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE • BLOCK_CIPHER_OPTION_STREAM_COMPLETE • BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED • BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_ALIGNED

Function

```
void BLOCK_CIPHER_CBC_Encrypt (DRV_HANDLE handle, uint8_t * cipherText,
                               uint32_t * numCipherBytes, uint8_t * plainText, uint32_t numPlainBytes,
                               void * key,      BLOCK_CIPHER_CBC_CONTEXT * context, uint32_t options);
```

1.7.1.3.4 BLOCK_CIPHER_CBC_Decrypt Function

Decrypts cipher text using cipher-block chaining mode.

File

block_cipher_mode_cbc.h

Syntax

```
void BLOCK_CIPHER_CBC_Decrypt(DRV_HANDLE handle, uint8_t * plainText, uint32_t * numPlainBytes, uint8_t * cipherText, uint32_t numCipherBytes, void * key, BLOCK_CIPHER_CBC_CONTEXT * context, uint32_t options);
```

Module

CBC

Returns

None

Description

Decrypts cipher text using cipher-block chaining mode.

Preconditions

The CBC context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

Example

```
// ****
// Decrypt data in CBC mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// CBC mode context
BLOCK_CIPHER_CBC_CONTEXT context;

// Initialization vector for CBC mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Cipher text to decrypt
static uint8_t cipher_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9,
0x3d, 0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e,
0xb7, 0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5,
0xfb, 0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad,
0x2b, 0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t plain_text[sizeof(cipher_text)];
// The number of bytes that were decrypted
uint32_t num_bytes_decrypted;

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
```

```

handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
and the AES block size
BLOCK_CIPHER_CBC_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector);

// Decrypt the data
BLOCK_CIPHER_CBC_Decrypt (handle, plain_text, &num_bytes_decrypted, (void *) cipher_text,
sizeof(cipher_text), &round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_START);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
plainText	The plain test produced by the decryption. This buffer must be a multiple of the block cipher's block size, even if the cipher text passed in is not.
numPlainBytes	Pointer to a uint32_t; the number of bytes decrypted will be returned in this parameter.
cipherText	The cipher text that will be decrypted. This buffer must be a multiple of the block size, unless this is the end of the stream (the BLOCK_CIPHER_OPTION_STREAM_COMPLETE option must be set in this case).
numCipherBytes	The number of cipher text bytes to decrypt.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this decryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher encryption options that the user can specify, or'd together. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_COMPLETE • • BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED • • BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_AIGNED

Function

```

void BLOCK_CIPHER_CBC_Decrypt (DRV_HANDLE handle, uint8_t * plainText,
uint32_t * numPlainBytes, uint8_t * cipherText, uint32_t numCipherBytes,
void * key,     BLOCK_CIPHER_CBC_CONTEXT * context, uint32_t options)

```

1.7.1.4 CFB

Describes functionality specific to the Cipher Feedback (CFB) block cipher mode of operation.

Functions

	Name	Description
◆	BLOCK_CIPHER_CFB_Initialize	Initializes a CFB context for encryption/decryption.
◆	BLOCK_CIPHER_CFB_Encrypt	Encrypts plain text using cipher feedback mode.
◆	BLOCK_CIPHER_CFB_Decrypt	Decrypts cipher text using cipher-block chaining mode.

Structures

Name	Description
BLOCK_CIPHER_CFB_CONTEXT	Context structure for a cipher feedback operation

Description

Describes functionality specific to the Cipher Feedback (CFB) block cipher mode of operation.

1.7.1.4.1 BLOCK_CIPHER_CFB_CONTEXT Structure

File

block_cipher_mode_cfb.h

Syntax

```
typedef struct {
    uint8_t initializationVector[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint32_t blockSize;
    BLOCK_CIPHER_FunctionEncrypt encrypt;
    BLOCK_CIPHER_FunctionDecrypt decrypt;
    uint8_t bytesRemaining;
} BLOCK_CIPHER_CFB_CONTEXT;
```

Members

Members	Description
uint8_t initializationVector[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Initialization vector for the CFB operation
uint32_t blockSize;	Block size of the cipher algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionEncrypt encrypt;	Encrypt function for the algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionDecrypt decrypt;	Decrypt function for the algorithm being used with the block cipher mode module
uint8_t bytesRemaining;	Number of bytes remaining in the remainingData buffer

Module

CFB

Description

Context structure for a cipher feedback operation

1.7.1.4.2 BLOCK_CIPHER_CFB_Initialize Function

Initializes a CFB context for encryption/decryption.

File

block_cipher_mode_cfb.h

Syntax

```
void BLOCK_CIPHER_CFB_Initialize(BLOCK_CIPHER_CFB_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction, BLOCK_CIPHER_FunctionDecrypt decryptFunction,
uint32_t blockSize, uint8_t * initializationVector);
```

Module

CFB

Returns

None.

Description

Initializes a CFB context for encryption/decryption. The user will specify details about the algorithm being used in CFB mode.

Preconditions

Any required initialization needed by the block cipher algorithm must have been performed.

Example

```
// Initialize the CFB block cipher module for use with AES.
SYS_MODULE_OBJ sysObject;
DRV_HANDLE handle;
BLOCK_CIPHER_CFB_CONTEXT context;
// Initialization vector for CFB mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

// Initialize the block cipher module
BLOCK_CIPHER_CFB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector);
```

Parameters

Parameters	Description
context	The CFB context to initialize.
encryptFunction	Pointer to the encryption function for the block cipher algorithm being used in CFB mode.
decryptFunction	Pointer to the decryption function for the block cipher algorithm being used in CFB mode.
blockSize	The block size of the block cipher algorithm being used in CFB mode.
initializationVector	The initialization vector for this operation. The length of this vector must be equal to the block size of your block cipher.

Function

```
void BLOCK_CIPHER_CFB_Initialize ( BLOCK_CIPHER_CFB_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction,
BLOCK_CIPHER_FunctionDecrypt decryptFunction, uint32_t blockSize,
uint8_t * initialization_vector)
```

1.7.1.4.3 BLOCK_CIPHER_CFB_Encrypt Function

Encrypts plain text using cipher feedback mode.

File

block_cipher_mode_cfb.h

Syntax

```
void BLOCK_CIPHER_CFB_Encrypt(DRV_HANDLE handle, uint8_t * cipherText, uint8_t * plainText,
uint32_t numBytes, void * key, BLOCK_CIPHER_CFB_CONTEXT * context, uint32_t options);
```

Module

CFB

Returns

None

Description

Encrypts plain text using cipher feedback mode.

Preconditions

The CFB context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

Example

```
// ****
// Encrypt data in CFB mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// CFB mode context
BLOCK_CIPHER_CFB_CONTEXT context;

// Initialization vector for CFB mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Plain text to encrypt
static uint8_t plain_text[] = {0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0x1c, 0x19, 0x1a, 0x0a, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
// The number of bytes that were encrypted
uint32_t num_bytes_encrypted;

// Initialization call for the AES module
sysObject = DRV_AES_Initialize(DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
```

```

    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_CFB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector);

//Encrypt the data
BLOCK_CIPHER_CFB_Encrypt (handle, cipher_text, &num_bytes_encrypted, (void *) plain_text,
sizeof(plain_text), &round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_START |
BLOCK_CIPHER_OPTION_USE_CFB1);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
cipherText	The cipher text produced by the encryption. This buffer must be a multiple of the block size, even if the plain text buffer size is not. This buffer should always be larger than the plain text buffer.
numCipherBytes	Pointer to a uint32_t; the number of bytes encrypted will be returned in this parameter.
plainText	The plain test to encrypt.
numPlainBytes	The number of plain text bytes that must be encrypted. If the number of plain text bytes encrypted is not evenly divisible by the block size, the remaining bytes will be cached in the CFB context structure until additional data is provided.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this encryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.

options	Block cipher encryption options that the user can specify, or'd together. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE • BLOCK_CIPHER_OPTION_STREAM_COMPLETE • BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED • BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_ALIGNED • BLOCK_CIPHER_OPTION_USE_CFB1 • BLOCK_CIPHER_OPTION_USE_CFB8 • BLOCK_CIPHER_OPTION_USE_CFB_BLOCK_SIZE
---------	---

Function

```
void BLOCK_CIPHER_CFB_Encrypt (DRV_HANDLE handle, uint8_t * cipherText,
                               uint32_t * numCipherBytes, uint8_t * plainText, uint32_t numPlainBytes,
                               void * key,      BLOCK_CIPHER_CFB_CONTEXT * context, uint32_t options);
```

1.7.1.4.4 BLOCK_CIPHER_CFB_Decrypt Function

Decrypts cipher text using cipher-block chaining mode.

File

block_cipher_mode_cfb.h

Syntax

```
void BLOCK_CIPHER_CFB_Decrypt (DRV_HANDLE handle, uint8_t * plainText, uint8_t * cipherText,
                               uint32_t numBytes, void * key, BLOCK_CIPHER_CFB_CONTEXT * context, uint32_t options);
```

Module

CFB

Returns

None

Description

Decrypts cipher text using cipher-block chaining mode.

Preconditions

The CFB context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

Example

```
// ****
// Decrypt data in CFB mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;
```

```

// CFB mode context
BLOCK_CIPHER_CFB_CONTEXT context;

// Initialization vector for CFB mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Cipher text to decrypt
static uint8_t cipher_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9,
0x3d, 0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e,
0xb7, 0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5,
0xfb, 0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad,
0x2b, 0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t plain_text[sizeof(cipher_text)];
// The number of bytes that were decrypted
uint32_t num_bytes_decrypted;

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

// Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_CFB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector);

// Decrypt the data
BLOCK_CIPHER_CFB_Decrypt (handle, plain_text, &num_bytes_decrypted, (void *) cipher_text,
sizeof(cipher_text), &round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_START |
BLOCK_CIPHER_USE_CFB1);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
plainText	The plain test produced by the decryption. This buffer must be a multiple of the block cipher's block size, even if the cipher text passed in is not.
numPlainBytes	Pointer to a uint32_t; the number of bytes decrypted will be returned in this parameter.

cipherText	The cipher text that will be decrypted. This buffer must be a multiple of the block size, unless this is the end of the stream (the BLOCK_CIPHER_OPTION_STREAM_COMPLETE option must be set in this case).
numCipherBytes	The number of cipher text bytes to decrypt.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this decryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	<p>Block cipher encryption options that the user can specify, or'd together. Valid options for this function are</p> <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_COMPLETE • BLOCK_CIPHER_OPTION_CIPHER_TEXT_POINTER_ALIGNED • BLOCK_CIPHER_OPTION_PLAIN_TEXT_POINTER_A_LIGNED • BLOCK_CIPHER_OPTION_USE_CFB1 • BLOCK_CIPHER_OPTION_USE_CFB8 • BLOCK_CIPHER_OPTION_USE_CFB_BLOCK_SIZE

Function

```
void BLOCK_CIPHER_CFB_Decrypt (DRV_HANDLE handle, uint8_t * plainText,
                               uint32_t * numPlainBytes, uint8_t * cipherText, uint32_t numCipherBytes,
                               void * key,     BLOCK_CIPHER_CFB_CONTEXT * context, uint32_t options)
```

1.7.1.5 OFB

Describes functionality specific to the Output Feedback (OFB) block cipher mode of operation.

Functions

	Name	Description
◆	BLOCK_CIPHER_OFB_Initialize	Initializes a OFB context for encryption/decryption.
◆	BLOCK_CIPHER_OFB_KeyStreamGenerate	Generates a key stream for use with the output feedback mode.
◆	BLOCK_CIPHER_OFB_Encrypt	Encrypts plain text using output feedback mode.
◆	BLOCK_CIPHER_OFB_Decrypt	Decrypts cipher text using output feedback mode.

Structures

Name	Description
BLOCK_CIPHER_OFB_CONTEXT	Context structure for the output feedback operation

Description

Describes functionality specific to the Output Feedback (OFB) block cipher mode of operation.

1.7.1.5.1 BLOCK_CIPHER_OFB_CONTEXT Structure

File

block_cipher_mode_ofb.h

Syntax

```
typedef struct {
    uint8_t initializationVector[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    BLOCK_CIPHER_FunctionEncrypt encrypt;
    BLOCK_CIPHER_FunctionDecrypt decrypt;
    void * keyStream;
    void * keyStreamCurrentPosition;
    uint32_t keyStreamSize;
    uint32_t bytesRemainingInKeyStream;
    uint32_t blockSize;
} BLOCK_CIPHER_OFB_CONTEXT;
```

Members

Members	Description
uint8_t initializationVector[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Initialization vector for the CFB operation
BLOCK_CIPHER_FunctionEncrypt encrypt;	Encrypt function for the algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionDecrypt decrypt;	Decrypt function for the algorithm being used with the block cipher mode module
void * keyStream;	Pointer to the key stream. Must be a multiple of the cipher's block size, but smaller than 2^{25} bytes.
void * keyStreamCurrentPosition;	Pointer to the current position in the key stream.
uint32_t keyStreamSize;	Size of the key stream.
uint32_t bytesRemainingInKeyStream;	Number of bytes remaining in the key stream
uint32_t blockSize;	Block size of the cipher algorithm being used with the block cipher mode module

Module

OFB

Description

Context structure for the output feedback operation

1.7.1.5.2 BLOCK_CIPHER_OFB_Initialize Function

Initializes a OFB context for encryption/decryption.

File

block_cipher_mode_ofb.h

Syntax

```
void BLOCK_CIPHER_OFB_Initialize(BLOCK_CIPHER_OFB_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction, BLOCK_CIPHER_FunctionDecrypt decryptFunction,
uint32_t blockSize, uint8_t * initializationVector, void * keyStream, uint32_t
keyStreamSize);
```

Module

OFB

Returns

None.

Description

Initializes a OFB context for encryption/decryption. The user will specify details about the algorithm being used in OFB mode.

Preconditions

Any required initialization needed by the block cipher algorithm must have been performed.

Example

```
// Initialize the OFB block cipher module for use with AES.
SYS_MODULE_OBJ sysObject;
DRV_HANDLE handle;
BLOCK_CIPHER_OFB_CONTEXT context;
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];
// Initialization vector for OFB mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

// Initialize the block cipher module
BLOCK_CIPHER_OFB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector, (void *)&keyStream, sizeof (keyStream));
```

Parameters

Parameters	Description
context	The OFB context to initialize.
encryptFunction	Pointer to the encryption function for the block cipher algorithm being used in OFB mode.
decryptFunction	Pointer to the decryption function for the block cipher algorithm being used in OFB mode.
blockSize	The block size of the block cipher algorithm being used in OFB mode.
initializationVector	The initialization vector for this operation. The length of this vector must be equal to the block size of your block cipher.
keyStream	Pointer to a buffer to contain a calculated keyStream.
keyStreamSize	The size of the keystream buffer, in bytes.

Function

```
void BLOCK_CIPHER_OFB_Initialize ( BLOCK_CIPHER_OFB_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction,
BLOCK_CIPHER_FunctionDecrypt decryptFunction, uint32_t blockSize,
uint8_t * initializationVector, void * keyStream, uint32_t keyStreamSize)
```

1.7.1.5.3 BLOCK_CIPHER_OFB_KeyStreamGenerate Function

Generates a key stream for use with the output feedback mode.

File

block_cipher_mode_ofb.h

Syntax

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_OFB_KeyStreamGenerate(DRV_HANDLE handle, uint32_t
numBlocks, void * key, BLOCK_CIPHER_OFB_CONTEXT * context, uint32_t options);
```

Module

OFB

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.
- BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.

Description

Generates a key stream for use with the output feedback mode.

Preconditions

The OFB context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The initializationVector parameter in the BLOCK_CIPHER_OFB_CONTEXT structure should be initialized. The size of this vector is the same as the block size of the cipher you are using.

Example

```
// ****
// Encrypt data in OFB mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// OFB mode context
BLOCK_CIPHER_OFB_CONTEXT context;

// Initialization vector for OFB mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Plain text to encrypt
static uint8_t plain_text[] = {0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a, 0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51, 0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef, 0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];

// Initialization call for the AES module
sysObject = DRV_AES_Initialize(DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{


```

```

    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys.  This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_OFB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector, (void *)&keyStream, sizeof (keyStream));

//Generate 4 blocks of key stream
BLOCK_CIPHER_OFB_KeyStreamGenerate(handle, 4, &round_keys, &context,
BLOCK_CIPHER_OPTION_STREAM_START);

//Encrypt the data
BLOCK_CIPHER_OFB_Encrypt (handle, cipher_text, (void *) plain_text, sizeof(plain_text),
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
numBlocks	The number of blocks of key stream that should be created. context->keyStream should have enough space remaining to handle this request.
key	The key to use when generating this key stream. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this operation. The first call of this function should have the context->initializationVector set. This value will be incremented for each block request.
options	Block cipher encryption options that the user can specify, or'd together. If BLOCK_CIPHER_OPTION_STREAM_START is not specified then BLOCK_CIPHER_OPTION_STREAM_CONTINUE is assumed. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE

Function

```

BLOCK_CIPHER_ERRORS BLOCK_CIPHER_OFB_KeyStreamGenerate (DRV_HANDLE handle,
uint32_t numBlocks, void * key,      BLOCK_CIPHER_OFB_CONTEXT * context,
uint32_t options)

```

1.7.1.5.4 BLOCK_CIPHER_OFB_Encrypt Function

Encrypts plain text using output feedback mode.

File

block_cipher_mode_ofb.h

Syntax

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_OFB_Encrypt(DRV_HANDLE handle, uint8_t * cipherText,
uint8_t * plainText, uint32_t numBytes, void * key, BLOCK_CIPHER_OFB_CONTEXT * context,
uint32_t options);
```

Module

OFB

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.
- BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.

Description

Encrypts plain text using output feedback mode.

Preconditions

The OFB context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The initializationVector parameter in the BLOCK_CIPHER_OFB_CONTEXT structure should be initialized. The size of this vector is the same as the block size of the cipher you are using.

Example

```
// ****
// Encrypt data in OFB mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// OFB mode context
BLOCK_CIPHER_OFB_CONTEXT context;

// Initialization vector for OFB mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Plain text to encrypt
static uint8_t plain_text[] = {0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0x0a, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];

// Initialization call for the AES module
sysObject = DRV_AES_Initialize(DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
```

```

    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_OFB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector, (void *)&keyStream, sizeof (keyStream));

//Generate 4 blocks of key stream
BLOCK_CIPHER_OFB_KeyStreamGenerate(handle, 4, &round_keys, &context,
BLOCK_CIPHER_OPTION_STREAM_START);

//Encrypt the data
BLOCK_CIPHER_OFB_Encrypt (handle, cipher_text, (void *) plain_text, sizeof(plain_text),
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
cipherText	The cipher text produced by the encryption. This buffer must be at least numBytes long.
plainText	The plain test to encrypt. Must be at least numBytes long.
numBytes	The number of plain text bytes that must be encrypted.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this encryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher encryption options that the user can specify, or'd together. If BLOCK_CIPHER_OPTION_STREAM_START is not specified then BLOCK_CIPHER_OPTION_STREAM_CONTINUE is assumed. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE

Function

```

BLOCK_CIPHER_ERRORS BLOCK_CIPHER_OFB_Encrypt (DRV_HANDLE handle,
uint8_t * cipherText, uint8_t * plainText, uint32_t numBytes,
void * key,      BLOCK_CIPHER_OFB_CONTEXT * context, uint32_t options)

```

1.7.1.5.5 BLOCK_CIPHER_OFB_Decrypt Function

Decrypts cipher text using output feedback mode.

File

block_cipher_mode_ofb.h

Syntax

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_OFB_Decrypt(DRV_HANDLE handle, uint8_t * plainText,
uint8_t * cipherText, uint32_t numBytes, void * key, BLOCK_CIPHER_OFB_CONTEXT * context,
uint32_t options);
```

Module

OFB

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.
- BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.

Description

Decrypts cipher text using output feedback mode.

Preconditions

The OFB context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The initializationVector parameter in the BLOCK_CIPHER_OFB_CONTEXT structure should be initialized. The size of this vector is the same as the block size of the cipher you are using.

Example

```
// ****
// Decrypt data in OFB mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// OFB mode context
BLOCK_CIPHER_OFB_CONTEXT context;

// Initialization vector for OFB mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Cipher text to decrypt
static uint8_t cipher_text[] = {0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9,
0x3d, 0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The decryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain decrypted ciphertext
```

```

uint8_t plain_text[sizeof(cipher_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_OFB_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector, (void *)&keyStream, sizeof (keyStream));

//Generate 4 blocks of key stream
BLOCK_CIPHER_OFB_KeyStreamGenerate(handle, 4, &round_keys, &context,
BLOCK_CIPHER_OPTION_STREAM_START);

// Decrypt the data
BLOCK_CIPHER_OFB_Decrypt (handle, plain_text, (void *) cipher_text, sizeof(cipher_text),
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
plainText	The plain text produced by the decryption. This buffer must be at least numBytes long.
cipherText	The cipher test to decrypt. Must be at least numBytes long.
numBytes	The number of cipher text bytes that must be decrypted.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this decryption. The first call of this function should have the context->initializationVector set to the initialization vector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher decryption options that the user can specify, or'd together. If BLOCK_CIPHER_OPTION_STREAM_START is not specified then BLOCK_CIPHER_OPTION_STREAM_CONTINUE is assumed. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE

Function

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_OFB_Decrypt (DRV_HANDLE handle,
uint8_t * plainText, uint8_t * cipherText, uint32_t numBytes,
void * key, BLOCK_CIPHER_OFB_CONTEXT * context, uint32_t options)
```

1.7.1.6 CTR

Describes functionality specific to the Counter (CTR) block cipher mode of operation.

Functions

	Name	Description
◆	BLOCK_CIPHER_CTR_Initialize	Initializes a CTR context for encryption/decryption.
◆	BLOCK_CIPHER_CTR_KeyStreamGenerate	Generates a key stream for use with the counter mode.
◆	BLOCK_CIPHER_CTR_Encrypt	Encrypts plain text using counter mode.
◆	BLOCK_CIPHER_CTR_Decrypt	Decrypts cipher text using counter mode.

Structures

Name	Description
BLOCK_CIPHER_CTR_CONTEXT	Context structure for the counter operation

Description

Describes functionality specific to the Counter (CTR) block cipher mode of operation.

1.7.1.6.1 BLOCK_CIPHER_CTR_CONTEXT Structure

File

block_cipher_mode_ctr.h

Syntax

```
typedef struct {
    uint8_t noncePlusCounter[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint8_t counter[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    BLOCK_CIPHER_FunctionEncrypt encrypt;
    BLOCK_CIPHER_FunctionDecrypt decrypt;
    void * keyStream;
    void * keyStreamCurrentPosition;
    uint32_t keyStreamSize;
    uint32_t bytesRemainingInKeyStream;
    uint32_t blockSize;
} BLOCK_CIPHER_CTR_CONTEXT;
```

Members

Members	Description
uint8_t noncePlusCounter[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer containing the initial NONCE and counter.
uint8_t counter[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer containing the current counter value.
BLOCK_CIPHER_FunctionEncrypt encrypt;	Encrypt function for the algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionDecrypt decrypt;	Decrypt function for the algorithm being used with the block cipher mode module
void * keyStream;	Pointer to the key stream. Must be a multiple of the cipher's block size, but smaller than 2^{25} bytes.

void * keyStreamCurrentPosition;	Pointer to the current position in the key stream.
uint32_t keyStreamSize;	Size of the key stream.
uint32_t bytesRemainingInKeyStream;	Number of bytes remaining in the key stream
uint32_t blockSize;	Block size of the cipher algorithm being used with the block cipher mode module

Module

CTR

Description

Context structure for the counter operation

1.7.1.6.2 BLOCK_CIPHER_CTR_Initialize Function

Initializes a CTR context for encryption/decryption.

File

block_cipher_mode_ctr.h

Syntax

```
void BLOCK_CIPHER_CTR_Initialize(BLOCK_CIPHER_CTR_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction, BLOCK_CIPHER_FunctionDecrypt decryptFunction,
uint32_t blockSize, uint8_t * noncePlusCounter, void * keyStream, uint32_t keyStreamSize);
```

Module

CTR

Returns

None.

Description

Initializes a CTR context for encryption/decryption. The user will specify details about the algorithm being used in CTR mode.

Preconditions

Any required initialization needed by the block cipher algorithm must have been performed.

Example

```
// Initialize the CTR block cipher module for use with AES.
SYS_MODULE_OBJ sysObject;
DRV_HANDLE handle;
BLOCK_CIPHER_CTR_CONTEXT context;
// Initialization vector for CTR mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];

sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

// Initialize the block cipher module
BLOCK_CIPHER_CTR_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector, (void *)&keyStream, sizeof (keyStream));
```

Parameters

Parameters	Description
context	The CTR context to initialize.
encryptFunction	Pointer to the encryption function for the block cipher algorithm being used in CTR mode.
decryptFunction	Pointer to the decryption function for the block cipher algorithm being used in CTR mode.
blockSize	The block size of the block cipher algorithm being used in CTR mode.
noncePlusCounter	A security nonce concatenated with the initial value of the counter for this operation. The counter can be 32, 64, or 128 bits, depending on the encrypt/decrypt options selected.
keyStream	Pointer to a buffer to contain a calculated keyStream.
keyStreamSize	The size of the keystream buffer, in bytes.

Function

```
void BLOCK_CIPHER_CTR_Initialize ( BLOCK_CIPHER_CTR_CONTEXT * context,
                                  BLOCK_CIPHER_FunctionEncrypt encryptFunction,
                                  BLOCK_CIPHER_FunctionDecrypt decryptFunction, uint32_t blockSize)
```

1.7.1.6.3 BLOCK_CIPHER_CTR_KeyStreamGenerate Function

Generates a key stream for use with the counter mode.

File

block_cipher_mode_ctr.h

Syntax

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_CTR_KeyStreamGenerate(DRV_HANDLE handle, uint32_t
numBlocks, void * key, BLOCK_CIPHER_CTR_CONTEXT * context, uint32_t options);
```

Module

CTR

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.
- BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.
- BLOCK_CIPHER_ERROR_CTR_COUNTER_EXPIRED - The requesting call has caused the counter number to run out of unique combinations.

Description

Generates a key stream for use with the counter mode.

Preconditions

The CTR context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The noncePlusCounter parameter in the BLOCK_CIPHER_CTR_CONTEXT structure should be initialized. The size of this vector is the same as the block size of the cipher you are using.

Example

```
// ****
// Encrypt data in CTR mode with the AES algorithm.
```

```

// ****
// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// CTR mode context
BLOCK_CIPHER_CTR_CONTEXT context;

// Initialization vector for CTR mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Plain text to encrypt
static uint8_t plain_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0x0a, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_CTR_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector, (void *)&keyStream, sizeof (keyStream));

//Generate 4 blocks of key stream
BLOCK_CIPHER_CTR_KeyStreamGenerate(handle, 4, &round_keys, &context,
BLOCK_CIPHER_OPTION_STREAM_START);

//Encrypt the data
BLOCK_CIPHER_CTR_Encrypt (handle, cipher_text, (void *) plain_text, sizeof(plain_text),
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
numBlocks	The number of blocks of key stream that should be created. context->keyStream should have enough space remaining to handle this request.
key	The key to use when generating this key stream. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this operation. The first call of this function should have the context->noncePlusCounter set. This value will be incremented for each block request.
options	Block cipher encryption options that the user can specify, or'd together. If BLOCK_CIPHER_OPTION_STREAM_START is not specified then BLOCK_CIPHER_OPTION_STREAM_CONTINUE is assumed. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE • BLOCK_CIPHER_OPTION_CTR_32BIT • BLOCK_CIPHER_OPTION_CTR_64BIT • BLOCK_CIPHER_OPTION_CTR_128BIT

Function

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_CTR_KeyStreamGenerate (DRV_HANDLE handle,
uint32_t numBlocks, void * key, BLOCK_CIPHER_CTR_CONTEXT * context,
uint32_t options)
```

1.7.1.6.4 BLOCK_CIPHER_CTR_Encrypt Function

Encrypts plain text using counter mode.

File

block_cipher_mode_ctr.h

Syntax

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_CTR_Encrypt (DRV_HANDLE handle, uint8_t * cipherText,
uint8_t * plainText, uint32_t numBytes, void * key, BLOCK_CIPHER_CTR_CONTEXT * context,
uint32_t options);
```

Module

CTR

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.
- BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.
- BLOCK_CIPHER_ERROR_CTR_COUNTER_EXPIRED - The requesting call has caused the counter number to run out

of unique combinations.

Description

Encrypts plain text using counter mode.

Preconditions

The CTR context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The noncePlusCounter parameter in the BLOCK_CIPHER_CTR_CONTEXT structure should be initialized. The size of this vector is the same as the block size of the cipher you are using.

Example

```

// ****
// Encrypt data in CTR mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// CTR mode context
BLOCK_CIPHER_CTR_CONTEXT context;

// Initialization vector for CTR mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Plain text to encrypt
static uint8_t plain_text[] = {0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
// and the AES block size
BLOCK_CIPHER_CTR_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,

```

```

initialization_vector, (void *)&keyStream, sizeof(keyStream));

//Generate 4 blocks of key stream
BLOCK_CIPHER_CTR_KeyStreamGenerate(handle, 4, &round_keys, &context,
BLOCK_CIPHER_OPTION_STREAM_START);

//Encrypt the data
BLOCK_CIPHER_CTR_Encrypt (handle, cipher_text, (void *) plain_text, sizeof(plain_text),
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
cipherText	The cipher text produced by the encryption. This buffer must be at least numBytes long.
plainText	The plain test to encrypt. Must be at least numBytes long.
numBytes	The number of plain text bytes that must be encrypted.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this encryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher encryption options that the user can specify, or'd together. If BLOCK_CIPHER_OPTION_STREAM_START is not specified then BLOCK_CIPHER_OPTION_STREAM_CONTINUE is assumed. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE • BLOCK_CIPHER_OPTION_CTR_32BIT • BLOCK_CIPHER_OPTION_CTR_64BIT • BLOCK_CIPHER_OPTION_CTR_128BIT

Function

```

BLOCK_CIPHER_ERRORS BLOCK_CIPHER_CTR_Encrypt (DRV_HANDLE handle,
uint8_t * cipherText, uint8_t * plainText, uint32_t numBytes,
void * key, BLOCK_CIPHER_CTR_CONTEXT * context, uint32_t options)

```

1.7.1.6.5 BLOCK_CIPHER_CTR_Decrypt Function

Decrypts cipher text using counter mode.

File

block_cipher_mode_ctr.h

Syntax

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_CTR_Decrypt(DRV_HANDLE handle, uint8_t * plainText,
uint8_t * cipherText, uint32_t numBytes, void * key, BLOCK_CIPHER_CTR_CONTEXT * context,
uint32_t options);
```

Module

CTR

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.
- BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.
- BLOCK_CIPHER_ERROR_CTR_COUNTER_EXPIRED - The requesting call has caused the counter number to run out of unique combinations.

Description

Decrypts cipher text using counter mode.

Preconditions

The CTR context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The noncePlusCounter parameter in the BLOCK_CIPHER_CTR_CONTEXT structure should be initialized. The size of this vector is the same as the block size of the cipher you are using.

Example

```
// ****
// Decrypt data in CTR mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// CTR mode context
BLOCK_CIPHER_CTR_CONTEXT context;

// Initialization vector for CTR mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Cipher text to decrypt
static uint8_t cipher_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9,
0x3d, 0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The decryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain decrypted ciphertext
uint8_t plain_text[sizeof(cipher_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
```

```

if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
and the AES block size
BLOCK_CIPHER_CTR_Initialize (&context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector, (void *)&keyStream, sizeof (keyStream));

//Generate 4 blocks of key stream
BLOCK_CIPHER_CTR_KeyStreamGenerate(handle, 4, &round_keys, &context,
BLOCK_CIPHER_OPTION_STREAM_START);

// Decrypt the data
BLOCK_CIPHER_CTR_Decrypt (handle, plain_text, (void *) cipher_text, sizeof(cipher_text),
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
plainText	The plain text produced by the decryption. This buffer must be at least numBytes long.
cipherText	The cipher test to decrypt. Must be at least numBytes long.
numBytes	The number of cipher text bytes that must be decrypted.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this decryption. The first call of this function should have the context->noncePlusCounter set to the initialization vector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher decryption options that the user can specify, or'd together. If BLOCK_CIPHER_OPTION_STREAM_START is not specified then BLOCK_CIPHER_OPTION_STREAM_CONTINUE is assumed. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_STREAM_START • BLOCK_CIPHER_OPTION_STREAM_CONTINUE • BLOCK_CIPHER_OPTION_CTR_32BIT • BLOCK_CIPHER_OPTION_CTR_64BIT • BLOCK_CIPHER_OPTION_CTR_128BIT

Function

BLOCK_CIPHER_ERRORS BLOCK_CIPHER_CTR_Decrypt (DRV_HANDLE handle,

```
uint8_t * plainText, uint8_t * cipherText, uint32_t numBytes,
void * key,     BLOCK_CIPHER_CTR_CONTEXT * context, uint32_t options)
```

1.7.1.7 GCM

Describes functionality specific to the Galois/Counter Mode (GCM) block cipher mode of operation.

Functions

	Name	Description
≡	BLOCK_CIPHER_GCM_Initialize	Initializes a GCM context for encryption/decryption.
≡	BLOCK_CIPHER_GCM_KeyStreamGenerate	Generates a key stream for use with the Galois/counter mode.
≡	BLOCK_CIPHER_GCM_Encrypt	Encrypts/authenticates plain text using Galois/counter mode.
≡	BLOCK_CIPHER_GCM_Decrypt	Decrypts/authenticates plain text using Galois/counter mode.

Structures

Name	Description
BLOCK_CIPHER_GCM_CONTEXT	Context structure for the Galois counter operation

Description

Describes functionality specific to the Galois/Counter Mode (GCM) block cipher mode of operation.

1.7.1.7.1 BLOCK_CIPHER_GCM_CONTEXT Structure

File

block_cipher_mode_gcm.h

Syntax

```
typedef struct {
    uint8_t initializationVector[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint8_t counter[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint8_t hashSubKey[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint8_t authTag[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    uint8_t authBuffer[CRYPTO_CONFIG_BLOCK_MAX_SIZE];
    BLOCK_CIPHER_FunctionEncrypt encrypt;
    BLOCK_CIPHER_FunctionDecrypt decrypt;
    void * keyStream;
    void * keyStreamCurrentPosition;
    uint32_t keyStreamSize;
    uint32_t bytesRemainingInKeyStream;
    uint32_t blockSize;
    uint32_t cipherTextLen;
    uint32_t authDataLen;
    uint8_t authBufferLen;
    struct {
        uint8_t authCompleted : 1;
        uint8_t filler : 7;
    } flags;
} BLOCK_CIPHER_GCM_CONTEXT;
```

Members

Members	Description
uint8_t initializationVector[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer containing the initialization vector and initial counter.
uint8_t counter[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer containing the current counter value.
uint8_t hashSubKey[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer containing the calculated hash subkey
uint8_t authTag[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer containing the current authentication tag

uint8_t authBuffer[CRYPTO_CONFIG_BLOCK_MAX_SIZE];	Buffer containing data that has been encrypted but has not been authenticated
BLOCK_CIPHER_FunctionEncrypt encrypt;	Encrypt function for the algorithm being used with the block cipher mode module
BLOCK_CIPHER_FunctionDecrypt decrypt;	Decrypt function for the algorithm being used with the block cipher mode module
void * keyStream;	Pointer to the key stream. Must be a multiple of the cipher's block size, but smaller than 2^{25} bytes.
void * keyStreamCurrentPosition;	Pointer to the current position in the key stream.
uint32_t keyStreamSize;	Size of the key stream.
uint32_t bytesRemainingInKeyStream;	Number of bytes remaining in the key stream
uint32_t blockSize;	Block size of the cipher algorithm being used with the block cipher mode module
uint32_t cipherTextLen;	Current number of ciphertext bytes computed
uint32_t authDataLen;	Current number of non-ciphertext bytes authenticated
uint8_t authBufferLen;	Number of bytes in the auth Buffer
uint8_t authCompleted : 1;	Determines if authentication of non-encrypted data has been completed for this device.

Module

GCM

Description

Context structure for the Galois counter operation

1.7.1.7.2 BLOCK_CIPHER_GCM_Initialize Function

Initializes a GCM context for encryption/decryption.

File

block_cipher_mode_gcm.h

Syntax

```
void BLOCK_CIPHER_GCM_Initialize(DRV_HANDLE handle, BLOCK_CIPHER_GCM_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction, BLOCK_CIPHER_FunctionDecrypt decryptFunction,
uint32_t blockSize, uint8_t * initializationVector, uint32_t initializationVectorLen, void
* keyStream, uint32_t keyStreamSize, void * key);
```

Module

GCM

Returns

None.

Description

Initializes a GCM context for encryption/decryption. The user will specify details about the algorithm being used in GCM mode.

Preconditions

Any required initialization needed by the block cipher algorithm must have been performed.

Example

```
// Initialize the GCM block cipher module for use with AES.
SYS_MODULE_OBJ sysObject;
DRV_HANDLE handle;
BLOCK_CIPHER_GCM_CONTEXT context;
// Initialization vector for GCM mode
static uint8_t ivValue[12] = {0xca, 0xfe, 0xba, 0xbe, 0xfa, 0xce, 0xdb, 0xad, 0xde, 0xca, 0xf8, 0x88};
```

```

//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];
// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};
// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;

sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context
BLOCK_CIPHER_GCM_Initialize (handle, &context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
(uint8_t *)ivValue, 12, (void *)&keyStream, sizeof(keyStream), &round_keys);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
context	The GCM context to initialize.
encryptFunction	Pointer to the encryption function for the block cipher algorithm being used in GCM mode.
decryptFunction	Pointer to the decryption function for the block cipher algorithm being used in GCM mode.
blockSize	The block size of the block cipher algorithm being used in GCM mode.
initializationVector	A security nonce. See the GCM specification, section 8.2 for information about constructing initialization vectors.
initializationVectorLen	Length of the initialization vector, in bytes
keyStream	Pointer to a buffer to contain a calculated keyStream.
keyStreamSize	The size of the keystream buffer, in bytes.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using. The key is used by the Initialize function to calculate the hash subkey.

Function

```

void BLOCK_CIPHER_GCM_Initialize ( BLOCK_CIPHER_GCM_CONTEXT * context,
BLOCK_CIPHER_FunctionEncrypt encryptFunction,
BLOCK_CIPHER_FunctionDecrypt decryptFunction, uint32_t blockSize,
uint8_t * initializationVector, void * keyStream, uint32_t keyStreamSize)

```

1.7.1.7.3 BLOCK_CIPHER_GCM_KeyStreamGenerate Function

Generates a key stream for use with the Galois/counter mode.

File

block_cipher_mode_gcm.h

Syntax

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_GCM_KeyStreamGenerate(DRV_HANDLE handle, uint32_t
numBlocks, void * key, BLOCK_CIPHER_GCM_CONTEXT * context, uint32_t options);
```

Module

GCM

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.
- BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.
- BLOCK_CIPHER_ERROR_GCM_COUNTER_EXPIRED - The requesting call has caused the counter number to run out of unique combinations.

Description

Generates a key stream for use with the Galois/counter mode.

Preconditions

The GCM context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The initializationVector parameter in the BLOCK_CIPHER_GCM_CONTEXT structure should be initialized. The size of this vector is the same as the block size of the cipher you are using.

Example

```
// ****
// Encrypt data in GCM mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// GCM mode context
BLOCK_CIPHER_GCM_CONTEXT context;

// Initialization vector for GCM mode
static uint8_t initialization_vector[] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
0x08, 0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

// Plain text to encrypt
static uint8_t plain_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;

// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];
```

```

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context with the AES module encryption/decryption functions
and the AES block size
BLOCK_CIPHER_GCM_Initialize (handle, &context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
initialization_vector, 12, (void *)&keyStream, sizeof (keyStream), &round_keys);

//Generate 4 blocks of key stream
BLOCK_CIPHER_GCM_KeyStreamGenerate(handle, 4, &round_keys, &context,
BLOCK_CIPHER_OPTION_STREAM_START);

//Encrypt the data
BLOCK_CIPHER_GCM_Encrypt (handle, cipher_text, (void *) plain_text, sizeof(plain_text),
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE);
/* *****/
// Encrypt data in GCM mode with the AES algorithm.
/* *****/

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// GCM mode context
BLOCK_CIPHER_GCM_CONTEXT context;

// Initialization vector for GCM mode
static uint8_t ivValue[12] = {0xca,0xfe,0xba,0xbe,0xfa,0xce,0xdb,0xad,0xde,0xca,0xf8,0x88};

// Data that will be authenticated, but not encrypted.
uint8_t authData[20] =
{0xfe,0xed,0xfa,0xce,0xde,0xad,0xbe,0xef,0xfe,0xed,0xfa,0xce,0xde,0xad,0xef,0xab,0xad,0xda,0xd2,};

// Plain text to encrypt
static uint8_t plain_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
    0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
    0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0x0a, 0x52, 0xef,
    0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];
// Structure to contain the calculated authentication tag
uint8_t tag[16];

```

```

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
// error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
// error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context
BLOCK_CIPHER_GCM_Initialize (handle, &context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
(uint8_t *)ivValue, 12, (void *)&keyStream, sizeof(keyStream), &round_keys);

//Generate 4 blocks of key stream
BLOCK_CIPHER_GCM_KeyStreamGenerate(handle, 4, &round_keys, &context, 0);

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
numBlocks	The number of blocks of key stream that should be created. context->keyStream should have enough space remaining to handle this request.
key	The key to use when generating this key stream. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this operation. The first call of this function should have the context->initializationVector set. This value will be incremented for each block request.
options	Block cipher encryption options that the user can specify, or'd together. This function currently does not support any options.

Function

```

BLOCK_CIPHER_ERRORS BLOCK_CIPHER_GCM_KeyStreamGenerate (DRV_HANDLE handle,
uint32_t numBlocks, void * key,      BLOCK_CIPHER_GCM_CONTEXT * context,
uint32_t options)

```

1.7.1.7.4 BLOCK_CIPHER_GCM_Encrypt Function

Encrypts/authenticates plain text using Galois/counter mode.

File

block_cipher_mode_gcm.h

Syntax

```

BLOCK_CIPHER_ERRORS BLOCK_CIPHER_GCM_Encrypt (DRV_HANDLE handle, uint8_t * cipherText,
uint8_t * plainText, uint32_t numBytes, uint8_t * authenticationTag, uint8_t tagLen, void *
key, BLOCK_CIPHER_GCM_CONTEXT * context, uint32_t options);

```

Module

GCM

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.
- BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.
- BLOCK_CIPHER_ERROR_GCM_COUNTER_EXPIRED - The requesting call has caused the counter number to run out of unique combinations.

Description

Encrypts/authenticates plain text using Galois/counter mode. This function accepts a combination of data that must be authenticated but not encrypted, and data that must be authenticated and encrypted. The user should initialize a GCM context using BLOCK_CIPHER_GCM_Initialize, then pass all authenticated-but-not-encrypted data into this function with the BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY option, and then pass any authenticated-and-encrypted data in using the BLOCK_CIPHER_OPTION_STREAM_CONTINUE option. When calling this function for the final time, the user must use the BLOCK_CIPHER_OPTION_STREAM_COMPLETE option to generate padding required to compute the authentication tag successfully. Note that BLOCK_CIPHER_OPTION_STREAM_COMPLETE must always be specified at the end of a stream, even if no encryption is being done.

The GMAC (Galois Message Authentication Code) mode can be used by using GCM without providing any data to encrypt (e.g. by only using BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY and BLOCK_CIPHER_OPTION_STREAM_COMPLETE options).

Preconditions

The GCM context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The initializationVector parameter in the BLOCK_CIPHER_GCM_CONTEXT structure should be initialized. See section 8.2 of the GCM specification for more information.

Example

```
// ****
// Encrypt data in GCM mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// GCM mode context
BLOCK_CIPHER_GCM_CONTEXT context;

// Initialization vector for GCM mode
static uint8_t ivValue[12] = {0xca, 0xfe, 0xba, 0xbe, 0xfa, 0xce, 0xdb, 0xad, 0xde, 0xca, 0xf8, 0x88};

// Data that will be authenticated, but not encrypted.
uint8_t authData[20] =
{0xfe, 0xed, 0xfa, 0xce, 0xde, 0xad, 0xbe, 0xef, 0xfe, 0xed, 0xfa, 0xce, 0xde, 0xad, 0xef, 0xab, 0xad, 0xda, 0xd2, };

// Plain text to encrypt
static uint8_t plain_text[] = { 0x6b, 0xc1, 0xbe, 0xe2, 0x2e, 0x40, 0x9f, 0x96, 0xe9, 0x3d,
0x7e, 0x11, 0x73, 0x93, 0x17, 0x2a,
0xae, 0x2d, 0x8a, 0x57, 0x1e, 0x03, 0xac, 0x9c, 0x9e, 0xb7,
0x6f, 0xac, 0x45, 0xaf, 0x8e, 0x51,
0x30, 0xc8, 0x1c, 0x46, 0xa3, 0x5c, 0xe4, 0x11, 0xe5, 0xfb,
0xc1, 0x19, 0x1a, 0xa, 0x52, 0xef,
0xf6, 0x9f, 0x24, 0x45, 0xdf, 0x4f, 0x9b, 0x17, 0xad, 0x2b,
0x41, 0x7b, 0xe6, 0x6c, 0x37, 0x10};

// The encryption key
static uint8_t AESKey128[] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab, 0xf7,
0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};
```

```

// Structure to contain the created AES round keys
AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain encrypted plaintext
uint8_t cipher_text[sizeof(plain_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];
// Structure to contain the calculated authentication tag
uint8_t tag[16];

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context
BLOCK_CIPHER_GCM_Initialize (handle, &context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
(uint8_t *)ivValue, 12, (void *)&keyStream, sizeof(keyStream), &round_keys);

//Generate 4 blocks of key stream
BLOCK_CIPHER_GCM_KeyStreamGenerate(handle, 4, &round_keys, &context, 0);

// Authenticate the non-encrypted data
if (BLOCK_CIPHER_GCM_Encrypt (handle, NULL, (uint8_t *)authData, 20, NULL, 0, &round_keys,
&context, BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY) != BLOCK_CIPHER_ERROR_NONE)
{
    // An error occurred
    while(1);
}

// As an example, this data will be encrypted in two blocks, to demonstrate how to use the
// options.
// Encrypt the first forty bytes of data.
// Note that at this point, you don't really need to specify the tag pointer or its
// length. This parameter only
// needs to be specified when the BLOCK_CIPHER_OPTION_STREAM_COMPLETE option is used.
if (BLOCK_CIPHER_GCM_Encrypt (handle, cipherText, (uint8_t *)ptShort, 40, tag, 16,
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE) != BLOCK_CIPHER_ERROR_NONE)
{
    // An error occurred
    while(1);
}

//Encrypt the final twenty bytes of data.
// Since we are using BLOCK_CIPHER_OPTION_STREAM_COMPLETE, we must specify a pointer to and
// length of the tag array, to store the auth tag.
if (BLOCK_CIPHER_GCM_Encrypt (handle, cipherText + 40, (uint8_t *)ptShort + 40, 20, tag,
16, &round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_COMPLETE) != BLOCK_CIPHER_ERROR_NONE)
{
    // An error occurred
    while(1);
}

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.

cipherText	The cipher text produced by the encryption. This buffer must be at least numBytes long.
plainText	The plain test to encrypt. Must be at least numBytes long.
numBytes	The number of plain text bytes that must be encrypted.
authenticationTag	Pointer to a structure to contain the authentication tag generated by a series of authentications. The tag will be written to this buffer when the user specifies the BLOCK_CIPHER_OPTION_STREAM_COMPLETE option.
tagLen	The length of the authentication tag, in bytes. 16 bytes is standard. Shorter byte lengths can be used, but they provide less reliable authentication.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this encryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher encryption options that the user can specify, or'd together. If no option is specified then BLOCK_CIPHER_OPTION_STREAM_CONTINUE is assumed. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY • BLOCK_CIPHER_OPTION_STREAM_CONTINUE • BLOCK_CIPHER_OPTION_STREAM_COMPLETE

Function

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_GCM_Encrypt (DRV_HANDLE handle,
uint8_t * cipherText, uint8_t * plainText, uint32_t numBytes,
uint8_t * authenticationTag, uint8_t tagLen, void * key,
BLOCK_CIPHER_GCM_CONTEXT * context, uint32_t options)
```

1.7.1.7.5 BLOCK_CIPHER_GCM_Decrypt Function

Decrypts/authenticates plain text using Galois/counter mode.

File

block_cipher_mode_gcm.h

Syntax

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_GCM_Decrypt (DRV_HANDLE handle, uint8_t * plainText,
uint8_t * cipherText, uint32_t numBytes, uint8_t * authenticationTag, uint8_t tagLen, void
* key, BLOCK_CIPHER_GCM_CONTEXT * context, uint32_t options);
```

Module

GCM

Returns

Returns a member of the BLOCK_CIPHER_ERRORS enumeration:

- BLOCK_CIPHER_ERROR_NONE - no error.

- **BLOCK_CIPHER_ERROR_KEY_STREAM_GEN_OUT_OF_SPACE** - There was not enough room remaining in the context->keyStream buffer to fit the key data requested by the numBlocks parameter.
- **BLOCK_CIPHER_ERROR_GCM_COUNTER_EXPIRED** - The requesting call has caused the counter number to run out of unique combinations.
- **BLOCK_CIPHER_ERROR_INVALID_AUTHENTICATION** - The calculated authentication tag did not match the one provided by the user.

Description

Decrypts/authenticates plain text using Galois/counter mode. This function accepts a combination of data that must be authenticated but not decrypted, and data that must be authenticated and decrypted. The user should initialize a GCM context using **BLOCK_CIPHER_GCM_Initialize**, then pass all authenticated-but-not-decrypted data into this function with the **BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY** option, and then pass any authenticated-and-decrypted data in using the **BLOCK_CIPHER_OPTION_STREAM_CONTINUE** option. When calling this function for the final time, the user must use the **BLOCK_CIPHER_OPTION_STREAM_COMPLETE** option to generate padding required to compute the authentication tag successfully. Note that **BLOCK_CIPHER_OPTION_STREAM_COMPLETE** must always be specified at the end of a stream, even if no encryption is being done.

The GMAC (Galois Message Authentication Code) mode can be used by using GCM without providing any data to decrypt (e.g. by only using **BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY** and **BLOCK_CIPHER_OPTION_STREAM_COMPLETE** options).

Preconditions

The GCM context must be initialized with the block cipher encrypt/decrypt functions and the block cipher algorithm's block size. The block cipher module must be initialized, if necessary.

The initializationVector parameter in the **BLOCK_CIPHER_GCM_CONTEXT** structure should be initialized. See section 8.2 of the GCM specification for more information.

Example

```

// ****
// Decrypt data in GCM mode with the AES algorithm.
// ****

// System module object variable (for initializing AES)
SYS_MODULE_OBJ sysObject;

// Drive handle variable, to describe which AES module to use
DRV_HANDLE handle;

// GCM mode context
BLOCK_CIPHER_GCM_CONTEXT context;

// Initialization vector for GCM mode
static uint8_t ivValue[12] = {0xca, 0xfe, 0xba, 0xbe, 0xfa, 0xce, 0xdb, 0xad, 0xde, 0xca, 0xf8, 0x88};

// Data that will be authenticated, but not decrypted.
uint8_t authData[20] =
{0xfe, 0xed, 0xfa, 0xce, 0xde, 0xad, 0xbe, 0xef, 0xfe, 0xed, 0xfa, 0xce, 0xde, 0xad, 0xbe, 0xef, 0xab, 0xad, 0xda, 0xd2, };

// Cipher text to decrypt
static uint8_t cipher_text[] = { 0x42, 0x83, 0x1e, 0xc2, 0x21, 0x77, 0x74, 0x24, 0x4b,
0x72, 0x21, 0xb7, 0x84, 0xd0, 0xd4, 0x9c,
0xe3, 0xaa, 0x21, 0x2f, 0x2c, 0x02, 0xa4, 0xe0, 0x35, 0xc1,
0x7e, 0x23, 0x29, 0xac, 0xa1, 0x2e,
0x21, 0xd5, 0x14, 0xb2, 0x54, 0x66, 0x93, 0x1c, 0x7d, 0x8f,
0x6a, 0x5a, 0xac, 0x84, 0xaa, 0x05,
0x1b, 0xa3, 0x0b, 0x39, 0x6a, 0xa, 0xac, 0x97, 0x3d, 0x58,
0xe0, 0x91, };

// The decryption key
static uint8_t AESKey128[] =
{0xff, 0xe9, 0x92, 0x86, 0x65, 0x73, 0x1c, 0x6d, 0x6a, 0x8f, 0x94, 0x67, 0x30, 0x83, 0x08};

// Structure to contain the created AES round keys

```

```

AES_ROUND_KEYS_128_BIT round_keys;
// Buffer to contain decrypted ciphertext
uint8_t plain_text[sizeof(cipher_text)];
//keyStream could also be allocated memory instead of fixed memory
uint8_t keyStream[AES_BLOCK_SIZE*4];
// The authentication tag for our ciphertext and our authData.
uint8_t tag[] = {0x5b, 0xc9, 0x4f, 0xbc, 0x32, 0x21, 0xa5, 0xdb, 0x94, 0xfa, 0xe9, 0x5a,
0xe7, 0x12, 0x1a, 0x47,};

// Initialization call for the AES module
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

// Driver open call for the AES module
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

//Create the AES round keys. This only needs to be done once for each AES key.
AES_RoundKeysCreate (&round_keys, (uint8_t*)AESKey128, AES_KEY_SIZE_128_BIT);

// Initialize the Block Cipher context
BLOCK_CIPHER_GCM_Initialize (handle, &context, AES_Encrypt, AES_Decrypt, AES_BLOCK_SIZE,
(uint8_t *)ivValue, 12, (void *)&keyStream, sizeof(keyStream), &round_keys);

//Generate 4 blocks of key stream
BLOCK_CIPHER_GCM_KeyStreamGenerate(handle, 4, &round_keys, &context, 0);

// Authenticate the non-encrypted data
if (BLOCK_CIPHER_GCM_Decrypt (handle, NULL, (uint8_t *)authData, 20, NULL, 0, &round_keys,
&context, BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY) != BLOCK_CIPHER_ERROR_NONE)
{
    // An error occurred
    while(1);
}

// As an example, this data will be decrypted in two blocks, to demonstrate how to use the
// options.
// Decrypt the first forty bytes of data.
// Note that at this point, you don't really need to specify the tag pointer or its
length. This parameter only
// needs to be specified when the BLOCK_CIPHER_OPTION_STREAM_COMPLETE option is used.
if (BLOCK_CIPHER_GCM_Decrypt (handle, plain_text, (uint8_t *)cipher_text, 40, tag, 16,
&round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_CONTINUE) != BLOCK_CIPHER_ERROR_NONE)
{
    // An error occurred
    while(1);
}

// Decrypt the final twenty bytes of data.
// Since we are using BLOCK_CIPHER_OPTION_STREAM_COMPLETE, we must specify the
authentication tag and its length. If it does not match
// the tag we obtain by decrypting the data, the Decrypt function will return
BLOCK_CIPHER_ERROR_INVALID_AUTHENTICATION.
if (BLOCK_CIPHER_GCM_Decrypt (handle, plain_text + 40, (uint8_t *)cipher_text + 40, 20,
tag, 16, &round_keys, &context, BLOCK_CIPHER_OPTION_STREAM_COMPLETE) !=
BLOCK_CIPHER_ERROR_NONE)
{
    // An error occurred
    while(1);
}

```

Parameters

Parameters	Description
handle	A handle that is passed to the block cipher's encrypt/decrypt functions to specify which instance of the block cipher module to use. This parameter can be specified as NULL if the block cipher does not have multiple instances.
plainText	The cipher text produced by the decryption. This buffer must be at least numBytes long.
cipherText	The cipher test to decrypt. Must be at least numBytes long.
numBytes	The number of cipher text bytes that must be decrypted.
authenticationTag	Pointer to a structure containing the authentication tag generated by an encrypt/authenticate operation. The tag calculated during decryption will be checked against this buffer when the user specifies the BLOCK_CIPHER_OPTION_STREAM_COMPLETE option.
tagLen	The length of the authentication tag, in bytes.
key	The key to use when encrypting/decrypting the data. The format of this key will depend on the block cipher you are using.
context	Pointer to a context structure for this decryption. The first call of this function should have the context->initializationVector set to the initializationVector. The same context structure instance should be used for every call used for the same data stream. The contents of this structure should not be changed by the user once the encryption/decryption has started.
options	Block cipher decryption options that the user can specify, or'd together. If no option is specified then BLOCK_CIPHER_OPTION_STREAM_CONTINUE is assumed. Valid options for this function are <ul style="list-style-type: none"> • BLOCK_CIPHER_OPTION_AUTHENTICATE_ONLY • BLOCK_CIPHER_OPTION_STREAM_CONTINUE • BLOCK_CIPHER_OPTION_STREAM_COMPLETE

Function

```
BLOCK_CIPHER_ERRORS BLOCK_CIPHER_GCM_Decrypt (DRV_HANDLE handle,
uint8_t * plainText, uint8_t * cipherText, uint32_t numBytes,
uint8_t * authenticationTag, uint8_t tagLen, void * key,
BLOCK_CIPHER_GCM_CONTEXT * context, uint32_t options)
```

1.7.2 AES

This section describes the Application Programming Interface (API) functions of the AES module.

Functions

	Name	Description
💡	DRV_AES_Initialize	Initializes the data for the instance of the AES module.
💡	DRV_AES_Deinitialize	Deinitializes the instance of the AES module
💡	DRV_AES_Open	Opens a new client for the device instance.
💡	DRV_AES_Close	Closes an opened client

CRYPTO	AES_RoundKeysCreate	Creates a set of round keys from an AES key to be used in AES encryption and decryption of data blocks.
CRYPTO	AES_Encrypt	Encrypts a 128-bit block of data using the AES algorithm.
CRYPTO	AES_Decrypt	Decrypts a 128-bit block of data using the AES algorithm.

Macros

Name	Description
DRV_AES_HANDLE	Definition for a single drive handle for the software-only AES module
DRV_AES_INDEX	Map of the default drive index to drive index 0
DRV_AES_INDEX_0	Definition for a single drive index for the software-only AES module
DRV_AES_INDEX_COUNT	Number of drive indicies for this module
AES_BLOCK_SIZE	The AES block size (16 bytes)
AES_KEY_SIZE_128_BIT	Use an AES key length of 128-bits / 16 bytes.
AES_KEY_SIZE_192_BIT	Use an AES key length of 192-bits / 24 bytes.
AES_KEY_SIZE_256_BIT	Use an AES key length of 256-bits / 32 bytes.
AES_ROUND_KEYS	Definition for the AES module's Round Key structure. Depending on the configuration of the library, this could be defined as AES_ROUND_KEYS_128_BIT, AES_ROUND_KEYS_192_BIT, or AES_ROUND_KEYS_256_BIT.

Structures

Name	Description
AES_ROUND_KEYS_128_BIT	Definition of a 128-bit key to simplify the creation of a round key buffer for the AES_RoundKeysCreate() function.
AES_ROUND_KEYS_192_BIT	Definition of a 192-bit key to simplify the creation of a round key buffer for the AES_RoundKeysCreate() function.
AES_ROUND_KEYS_256_BIT	Definition of a 256-bit key to simplify the creation of a round key buffer for the AES_RoundKeysCreate() function.

Description

This section describes the Application Programming Interface (API) functions of the AES module.

1.7.2.1 DRV_AES_HANDLE Macro

File

aes.h

Syntax

```
#define DRV_AES_HANDLE ((DRV_HANDLE) 0)
```

Module

AES

Description

Definition for a single drive handle for the software-only AES module

1.7.2.2 DRV_AES_INDEX Macro

File

aes.h

Syntax

```
#define DRV_AES_INDEX DRV_AES_INDEX_0
```

Module

AES

Description

Map of the default drive index to drive index 0

1.7.2.3 DRV_AES_INDEX_0 Macro

File

aes.h

Syntax

```
#define DRV_AES_INDEX_0 0
```

Module

AES

Description

Definition for a single drive index for the software-only AES module

1.7.2.4 DRV_AES_INDEX_COUNT Macro

File

aes.h

Syntax

```
#define DRV_AES_INDEX_COUNT 1
```

Module

AES

Description

Number of drive indicies for this module

1.7.2.5 AES_BLOCK_SIZE Macro

File

aes.h

Syntax

```
#define AES_BLOCK_SIZE 16
```

Module

AES

Description

The AES block size (16 bytes)

1.7.2.6 AES_KEY_SIZE_128_BIT Macro

File

aes.h

Syntax

```
#define AES_KEY_SIZE_128_BIT 16
```

Module

AES

Description

Use an AES key length of 128-bits / 16 bytes.

1.7.2.7 AES_KEY_SIZE_192_BIT Macro

File

aes.h

Syntax

```
#define AES_KEY_SIZE_192_BIT 24
```

Module

AES

Description

Use an AES key length of 192-bits / 24 bytes.

1.7.2.8 AES_KEY_SIZE_256_BIT Macro

File

aes.h

Syntax

```
#define AES_KEY_SIZE_256_BIT 32
```

Module

AES

Description

Use an AES key length of 256-bits / 32 bytes.

1.7.2.9 AES_ROUND_KEYS Macro

File

aes.h

Syntax

```
#define AES_ROUND_KEYS AES_ROUND_KEYS_256_BIT
```

Module

AES

Description

Definition for the AES module's Round Key structure. Depending on the configuration of the library, this could be defined as AES_ROUND_KEYS_128_BIT, AES_ROUND_KEYS_192_BIT, or AES_ROUND_KEYS_256_BIT.

1.7.2.10 AES_ROUND_KEYS_128_BIT Structure

File

aes.h

Syntax

```
typedef struct {
    uint32_t key_length;
    uint32_t data[44];
} AES_ROUND_KEYS_128_BIT;
```

Members

Members	Description
uint32_t key_length;	Length of the key
uint32_t data[44];	Round keys

Module

AES

Description

Definition of a 128-bit key to simplify the creation of a round key buffer for the AES_RoundKeysCreate() function.

1.7.2.11 AES_ROUND_KEYS_192_BIT Structure

File

aes.h

Syntax

```
typedef struct {
    uint32_t key_length;
    uint32_t data[52];
} AES_ROUND_KEYS_192_BIT;
```

Members

Members	Description
uint32_t key_length;	Length of the key
uint32_t data[52];	Round keys

Module

AES

Description

Definition of a 192-bit key to simplify the creation of a round key buffer for the AES_RoundKeysCreate() function.

1.7.2.12 AES_ROUND_KEYS_256_BIT Structure

File

aes.h

Syntax

```
typedef struct {
    uint32_t key_length;
    uint32_t data[60];
} AES_ROUND_KEYS_256_BIT;
```

Members

Members	Description
uint32_t key_length;	Length of the key
uint32_t data[60];	Round keys

Module

AES

Description

Definition of a 256-bit key to simplify the creation of a round key buffer for the AES_RoundKeysCreate() function.

1.7.2.13 DRV_AES_Initialize Function

Initializes the data for the instance of the AES module.

File

aes.h

Syntax

```
SYS_MODULE_OBJ DRV_AES_Initialize(const SYS_MODULE_INDEX index, const SYS_MODULE_INIT *  
const init);
```

Module

AES

Returns

If successful, returns a valid handle to a driver instance object. Otherwise, it returns SYS_MODULE_OBJ_INVALID

Description

This routine initializes data for the instance of the AES module. For pure software implementations, the function has no effect.

Preconditions

None

Example

```
SYS_MODULE_OBJ sysObject;  
  
sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);  
if (sysObject != SYS_MODULE_OBJ_STATIC)  
{  
    // error  
}
```

Parameters

Parameters	Description
index	Identifier for the instance to be initialized
init	Pointer to the data structure containing any data necessary to initialize the hardware. This pointer may be null if no data is required and default initialization is to be used

Function

```
SYS_MODULE_OBJ DRV_AES_Initialize(const SYS_MODULE_INDEX index,
const SYS_MODULE_INIT * const init)
```

1.7.2.14 DRV_AES_Deinitialize Function

Deinitializes the instance of the AES module

File

aes.h

Syntax

```
void DRV_AES_Deinitialize(SYS_MODULE_OBJ object);
```

Module

AES

Returns

None

Description

Deinitializes the specific module instance disabling its operation. For pure software implementations, this function has no effect.

Preconditions

None

Example

```
SYS_MODULE_OBJ sysObject;

sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

DRV_AES_Deinitialize (sysObject);
```

Parameters

Parameters	Description
object	Identifier for the instance to be de-initialized

Function

```
void DRV_AES_Deinitialize(SYS_MODULE_OBJ object)
```

1.7.2.15 DRV_AES_Open Function

Opens a new client for the device instance.

File

aes.h

Syntax

```
DRV_HANDLE DRV_AES_Open(const SYS_MODULE_INDEX index, const DRV_IO_INTENT ioIntent);
```

Module

AES

Returns

None

Description

Returns a handle of the opened client instance. All client operation APIs will require this handle as an argument.

Preconditions

The driver must have been previously initialized and in the initialized state.

Example

```
SYS_MODULE_OBJ sysObject;
DRV_HANDLE handle;

sysObject = DRV_AES_Initialize (DRV_AES_INDEX, NULL);
if (sysObject != SYS_MODULE_OBJ_STATIC)
{
    // error
}

handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}
```

Parameters

Parameters	Description
index	Identifier for the instance to opened
ioIntent	Possible values from the enumeration DRV_IO_INTENT There are currently no applicable values for this module.

Function

```
DRV_HANDLE DRV_AES_Open(const SYS_MODULE_INDEX index,
const DRV_IO_INTENT ioIntent)
```

1.7.2.16 DRV_AES_Close Function

Closes an opened client

File

aes.h

Syntax

```
void DRV_AES_Close (DRV_HANDLE handle);
```

Module

AES

Returns

None

Description

Closes an opened client, resets the data structure and removes the client from the driver.

Preconditions

None.

Example

```
handle = DRV_AES_Open (DRV_AES_INDEX, 0);
if (handle != DRV_AES_HANDLE)
{
    // error
}

DRV_AES_Close (handle);
```

Parameters

Parameters	Description
handle	The handle of the opened client instance returned by DRV_AES_Open().

Function

```
void DRV_AES_Close (DRV_HANDLE handle)
```

1.7.2.17 AES_RoundKeysCreate Function

Creates a set of round keys from an AES key to be used in AES encryption and decryption of data blocks.

File

aes.h

Syntax

```
void AES_RoundKeysCreate (void* round_keys, uint8_t* key, uint8_t key_size);
```

Module

AES

Returns

None

Description

This routine takes an AES key and performs a key schedule to expand the key into a number of separate set of round keys. These keys are commonly known as the Rijndael key schedule or a session key.

Preconditions

None.

Example

```
static const uint8_t AESKey128[] = { 0x95, 0xA8, 0xEE, 0x8E,
                                    0x89, 0x97, 0x9B, 0x9E,
                                    0xFD, 0xCB, 0xC6, 0xEB,
                                    0x97, 0x97, 0x52, 0x8D
                                };
AES_ROUND_KEYS_128_BIT round_keys;

AES_RoundKeysCreate(    &round_keys,
                      AESKey128,
                      AES_KEY_SIZE_128_BIT
                  );
```

Parameters

Parameters	Description
round_keys	Pointer to the output buffer that will contain the expanded short key (Rijndael) schedule/ session key. This is to be used in the encryption and decryption routines. The round_keys buffer must be word aligned for the target processor.
key key_size	The input key which can be 128, 192, or 256 bits in length. Specifies the key length in bytes. Valid options are: <ul style="list-style-type: none"> • AES_KEY_SIZE_128_BIT • AES_KEY_SIZE_192_BIT • AES_KEY_SIZE_256_BIT The values 16, 24, and 32 may also be used instead of the above definitions.

Function

```
void AES_RoundKeysCreate( void* round_keys,
  uint8_t* key,
  uint8_t key_size
)
```

1.7.2.18 AES_Encrypt Function

Encrypts a 128-bit block of data using the AES algorithm.

File

aes.h

Syntax

```
void AES_Encrypt(DRV_HANDLE handle, void * cipherText, void * plainText, void * key);
```

Module

AES

Returns

None

Description

Encrypts a 128-bit block of data using the AES algorithm.

Remarks

AES should be used the a block cipher mode of operation. See block_cipher_modes.h for more information.

Preconditions

The AES module must be configured and initialized, if necessary.

Parameters

Parameters	Description
handle	Pointer to the driver handle for the instance of the AES module you are using to encrypt the plainText. No function for pure software implementation.

cipherText	Buffer for the 128-bit output block of cipherText produced by encrypting the plainText.
plainText	The 128-bit block of plainText to encrypt.
key	Pointer to a set of round keys created by the AES_RoundKeysCreate function.

Function

```
void AES_Encrypt (DRV_HANDLE handle, void * cipherText, void * plainText, void * key)
```

1.7.2.19 AES_Decrypt Function

Decrypts a 128-bit block of data using the AES algorithm.

File

aes.h

Syntax

```
void AES_Decrypt (DRV_HANDLE handle, void * plainText, void * cipherText, void * key);
```

Module

AES

Returns

None.

Description

Decrypts a 128-bit block of data using the AES algorithm.

Remarks

AES should be used the a block cipher mode of operation. See block_cipher_modes.h for more information.

Preconditions

The AES module must be configured and initialized, if necessary.

Parameters

Parameters	Description
handle	Pointer to the driver handle for the instance of the AES module you are using to decrypt the cipherText. No function for pure software implementation.
plainText	Buffer for the 128-bit output block of plainText produced by decrypting the cipherText.
cipherText	The 128-bit block of cipherText to decrypt.
key	Pointer to a set of round keys created by the AES_RoundKeysCreate function.

Function

```
void AES_Decrypt (DRV_HANDLE handle, void * plainText, void * cipherText, void * key)
```

1.7.3 TDES

This section describes the Application Programming Interface (API) functions of the TDES module.

Functions

	Name	Description
◆	TDES_RoundKeysCreate	Creates a set of round keys from an TDES key to be used in TDES encryption and decryption of data blocks.
◆	TDES_Encrypt	Encrypts a 64-byte block of data using the Triple-DES algorithm.
◆	TDES_Decrypt	Decrypts a 64-byte block of data using the Triple-DES algorithm.

Macros

Name	Description
TDES_KEY_SIZE	Defines the TDES key size in bytes
TDES_BLOCK_SIZE	Defines the data block size for the TDES algorithm. The TDES algorithm uses a fixed 8 byte data block so this is defined as a constant that can be used to define or measure against the TDES data block size.

Structures

Name	Description
TDES_ROUND_KEYS	Definition to simplify the creation of a round key buffer for the TDES_RoundKeysCreate() function.

Description

This section describes the Application Programming Interface (API) functions of the TDES module.

1.7.3.1 TDES_KEY_SIZE Macro

File

tdes.h

Syntax

```
#define TDES_KEY_SIZE 8
```

Module

TDES

Description

Defines the TDES key size in bytes

1.7.3.2 TDES_BLOCK_SIZE Macro

File

tdes.h

Syntax

```
#define TDES_BLOCK_SIZE 8
```

Module

TDES

Description

Defines the data block size for the TDES algorithm. The TDES algorithm uses a fixed 8 byte data block so this is defined as a constant that can be used to define or measure against the TDES data block size.

1.7.3.3 TDES_ROUND_KEYS Structure

File

tdes.h

Syntax

```
typedef struct {
    uint32_t data[96];
} TDES_ROUND_KEYS;
```

Module

TDES

Description

Definition to simplify the creation of a round key buffer for the TDES_RoundKeysCreate() function.

1.7.3.4 TDES_RoundKeysCreate Function

Creates a set of round keys from an TDES key to be used in TDES encryption and decryption of data blocks.

File

tdes.h

Syntax

```
void TDES_RoundKeysCreate(void* roundKeys, uint8_t* key);
```

Module

TDES

Returns

None

Description

This routine takes an TDES key and performs a key expansion to expand the key into a number of separate set of round keys. These keys are commonly known as a Key Schedule, or subkeys.

Preconditions

None.

Example

```
static unsigned char __attribute__((aligned)) TDESKey[] = {
    0x25, 0x9d, 0xf1, 0x6e, 0x7a, 0xf8, 0x04, 0xfe,
    0x83, 0xb9, 0x0e, 0x9b, 0xf7, 0xc7, 0xe5, 0x57,
    0x25, 0x9d, 0xf1, 0x6e, 0x7a, 0xf8, 0x04, 0xfe
};

TDES_ROUND_KEYS round_keys;

TDES_RoundKeysCreate(&round_keys,
                    TDESKey
                    );
```

Parameters

Parameters	Description
roundKeys	[out] Pointer to the output buffer that will contain the expanded subkeys. This is to be used in the encryption and decryption routines. The round_keys buffer must be word aligned for the target processor.

key	[in] The input key which can be 192 bits in length. This key should be formed from three concatenated DES keys.
-----	---

Function

```
void TDES_RoundKeysCreate(void* roundKeys,
    uint8_t* key,
)
```

1.7.3.5 TDES_Encrypt Function

Encrypts a 64-byte block of data using the Triple-DES algorithm.

File

tdes.h

Syntax

```
void TDES_Encrypt(DRV_HANDLE handle, void* cipherText, void* plainText, void* key);
```

Module

TDES

Returns

None.

Description

Encrypts a 64-byte block of data using the Triple-DES algorithm.

Remarks

TDES should be used with a block cipher mode of operation. See block_cipher_modes.h for more information.

Preconditions

None

Parameters

Parameters	Description
handle	Pointer to the driver handle for an instance of a TDES module being used to encrypt the plaintext. This should be specified as NULL for the pure software implementation of TDES.
cipherText	Buffer for the 64-bit output block of cipherText produced by encrypting the plainText.
plainText	The 64-bit block of plainText to encrypt.
key	Pointer to a set of round keys created with the TDES_RoundKeysCreate function.

Function

```
void TDES_Encrypt(DRV_HANDLE handle, void* cipherText, void* plainText,
    void* key)
```

1.7.3.6 TDES_Decrypt Function

Decrypts a 64-byte block of data using the Triple-DES algorithm.

File

tdes.h

Syntax

```
void TDES_Decrypt(DRV_HANDLE handle, void* plain_text, void* cipher_text, void* key);
```

Module

TDES

Returns

None.

Description

Decrypts a 64-byte block of data using the Triple-DES algorithm.

Remarks

TDES should be used with a block cipher mode of operation. See `block_cipher_modes.h` for more information.

Preconditions

None

Parameters

Parameters	Description
handle	Pointer to the driver handle for an instance of a TDES module being used to decrypt the ciphertext. This should be specified as NULL for the pure software implementation of TDES.
plainText	Buffer for the 64-bit output block of plainText produced by decrypting the cipherText.
cipherText	The 64-bit block of cipherText to decrypt.
key	Pointer to a set of round keys created with the TDES_RoundKeysCreate function.

Function

```
void TDES_Decrypt(DRV_HANDLE handle, void* cipherText, void* plainText,  
void* key)
```

1.7.4 XTEA

This section describes the Application Programming Interface (API) functions of the XTEA module.

Functions

	Name	Description
≡	XTEA_Configure	Configures the XTEA module. None
≡	XTEA_Encrypt	Encrypts a 64-bit block of data using the XTEA algorithm. None
≡	XTEA_Decrypt	Decrypts a 64-bit block of data using the XTEA algorithm. None

Macros

Name	Description
XTEA_BLOCK_SIZE	The XTEA algorithm block size

Description

This section describes the Application Programming Interface (API) functions of the XTEA module.

1.7.4.1 XTEA_BLOCK_SIZE Macro

File

xtea.h

Syntax

```
#define XTEA_BLOCK_SIZE 8ul
```

Module

XTEA

Description

The XTEA algorithm block size

1.7.4.2 XTEA_Configure Function

File

xtea.h

Syntax

```
void XTEA_Configure(uint8_t iterations);
```

Module

XTEA

Side Effects

None

Returns

None

Description

Configures the XTEA module.

None

Remarks

This implementation is not thread-safe. If you are using XTEA for multiple applications in an preemptive operating system you must use the same number of iterations for all applications to avoid error.

Preconditions

None

Parameters

Parameters	Description
iterations	The number of iterations of the XTEA algorithm that the encrypt/decrypt functions should perform for each block encryption/decryption.

Function

```
void XTEA_Configure (uint8_t iterations)
```

1.7.4.3 XTEA_Encrypt Function

File

xtea.h

Syntax

```
void XTEA_Encrypt(DRV_HANDLE handle, uint32_t * cipherText, uint32_t * plainText, uint32_t
* key);
```

Module

XTEA

Side Effects

None

Returns

None

Description

Encrypts a 64-bit block of data using the XTEA algorithm.

None

Remarks

None

Preconditions

None

Parameters

Parameters	Description
handle	Provided for compatibility with the block cipher modes of operations module.
cipherText	Pointer to the 64-bit output buffer for the encrypted plainText.
plainText	Pointer to one 64-bit block of data to encrypt.
key	Pointer to the 128-bit key.

Function

```
void XTEA_Encrypt(DRV_HANDLE handle, uint32_t* data,
unsigned int dataLength, uint32_t * key)
```

1.7.4.4 XTEA_Decrypt Function

File

xtea.h

Syntax

```
void XTEA_Decrypt(DRV_HANDLE handle, uint32_t * plainText, uint32_t * cipherText, uint32_t
* key);
```

Module

XTEA

Side Effects

None

Returns

None

Description

Decrypts a 64-bit block of data using the XTEA algorithm.

None

Remarks

None

Preconditions

None

Parameters

Parameters	Description
handle	Provided for compatibility with the block cipher modes of operations module.
plainText	Pointer to the 64-bit output buffer for the decrypted plainText.
cipherText	Pointer to a 64-bit block of cipherText to decrypt.
key	Pointer to the 128-bit key.

Function

```
void XTEA_Decrypt(DRV_HANDLE handle, uint32_t* data,
unsigned int dataLength, uint32_t * key)
```

1.7.5 ARCFOUR

This section describes the Application Programming Interface (API) functions of the ARCFOUR module.

Functions

	Name	Description
🛡	ARCFOUR_CreateSBox	Initializes an ARCFOUR encryption stream.
🛡	ARCFOUR_Encrypt	Encrypts an array of data with the ARCFOUR algorithm.

Macros

Name	Description
ARCFOUR_Decrypt	Decrypts an array of data with the ARCFOUR algorithm.

Structures

Name	Description
ARCFOUR_CONTEXT	Encryption Context for ARCFOUR module. The program need not access any of these values directly, but rather only store the structure and use ARCFOUR_CreateSBox to set it up.

Description

This section describes the Application Programming Interface (API) functions of the ARCFOUR module.

1.7.5.1 ARCFOUR_CONTEXT Structure

File

arcfour.h

Syntax

```
typedef struct {
    uint8_t * sBox;
    uint8_t iterator;
    uint8_t coiterator;
} ARCFOUR_CONTEXT;
```

Members

Members	Description
uint8_t * sBox;	A pointer to a 256 byte S-box array
uint8_t iterator;	The iterator variable
uint8_t coiterator;	The co-iterator

Module

ARCFOUR

Description

Encryption Context for ARCFOUR module. The program need not access any of these values directly, but rather only store the structure and use ARCFOUR_CreateSBox to set it up.

1.7.5.2 ARCFOUR_CreateSBox Function

Initializes an ARCFOUR encryption stream.

File

arcfour.h

Syntax

```
void ARCFOUR_CreateSBox(ARCFOUR_CONTEXT* context, uint8_t * sBox, uint8_t* key, uint16_t key_length);
```

Module

ARCFOUR

Returns

None

Description

This function initializes an ARCFOUR encryption stream. Call this function to set up the initial state of the encryption context and the S-box. The S-box will be initialized to its zero state with the supplied key.

This function can be used to initialize for encryption and decryption.

Remarks

For security, the key should be destroyed after this call.

Preconditions

None.

Parameters

Parameters	Description
context	A pointer to the allocated encryption context structure
sBox	A pointer to a 256-byte buffer that will be used for the S-box.
key	A pointer to the key to be used
key_length	The length of the key, in bytes.

Function

```
void ARCFOUR_CreateSBox( ARCFOUR_CONTEXT* context, uint8_t* sBox,
                          uint8_t* key, uint16_t key_length)
```

1.7.5.3 ARCFOUR_Encrypt Function

Encrypts an array of data with the ARCFOUR algorithm.

File

arcfour.h

Syntax

```
void ARCFOUR_Encrypt(uint8_t* data, uint32_t data_length, ARCFOUR_CONTEXT* context);
```

Module

ARCFOUR

Returns

None

Description

This function uses the current ARCFOUR context to encrypt data in place.

Preconditions

The encryption context has been initialized with ARCFOUR_CreateSBox.

Parameters

Parameters	Description
data	The data to be encrypted (in place)
data_length	The length of data
context	A pointer to the initialized encryption context structure

Function

```
void ARCFOUR_Encrypt(uint8_t* data, uint32_t data_length,
                      ARCFOUR_CONTEXT* context)
```

1.7.5.4 ARCFOUR_Decrypt Macro

Decrypts an array of data with the ARCFOUR algorithm.

File

arcfour.h

Syntax

```
#define ARCFOUR_Decrypt ARCFOUR_Encrypt
```

Module

ARCFOUR

Returns

None

Description

This function uses the current ARCFOUR context to decrypt data in place.

Preconditions

The encryption context has been initialized with ARCFOUR_CreateSBox.

Parameters

Parameters	Description
data	The data to be encrypted (in place)
data_length	The length of data
context	A pointer to the initialized encryption context structure

Function

```
void ARCFOUR_Decrypt(uint8_t* data, uint32_t data_length,
                      ARCFOUR_CONTEXT* context)
```

1.7.6 RSA

This section describes the Application Programming Interface (API) functions of the RSA module.

Enumerations

Name	Description
DRV_RSA_OPERATION_MODES	Enumeration describing modes of operation used with RSA
DRV_RSA_PAD_TYPE	Enumeration describing the padding type that should be used with a message being encrypted
DRV_RSA_STATUS	Enumeration describing statuses that could apply to an RSA operation

Functions

	Name	Description
≡	DRV_RSA_Initialize	Initializes the data for the instance of the RSA module
≡	DRV_RSA_Deinitialize	Deinitializes the instance of the RSA module
≡	DRV_RSA_Open	Opens a new client for the device instance
≡	DRV_RSA_Close	Closes an opened client
≡	DRV_RSA_Configure	Configures the client instance
≡	DRV_RSA_Encrypt	Encrypts a message using a public RSA key
≡	DRV_RSA_Decrypt	Decrypts a message using a private RSA key
≡	DRV_RSA_Tasks	Maintains the driver's state machine by advancing a non-blocking encryption or decryption operation.
≡	DRV_RSA_ClientStatus	Returns the current state of the encryption/decryption operation

Macros

Name	Description
DRV_RSA_HANDLE	Definition for a single drive handle for the software-only RSA module
DRV_RSA_INDEX	Map of the default drive index to drive index 0

DRV_RSA_INDEX_0	Definition for a single drive index for the software-only RSA module
DRV_RSA_INDEX_COUNT	Number of drive indicies for this module

Structures

Name	Description
DRV_RSA_INIT	Initialization structure used for RSA.
DRV_RSA_PUBLIC_KEY	Structure describing the format of an RSA public key (used for encryption or verification)
DRV_RSA_PRIVATE_KEY_CRT	Structure describing the format of an RSA private key, in CRT format (used for decryption or signing)

Types

Name	Description
RSA_MODULE_ID	This is type RSA_MODULE_ID.
RSA_RandomGet	Global variable for the rand function used with this library.
DRV_RSA_RandomGet	Function pointer for the rand function type.

Description

This section describes the Application Programming Interface (API) functions of the RSA module.

1.7.6.1 DRV_RSA_HANDLE Macro

File

rsa.h

Syntax

```
#define DRV_RSA_HANDLE ((DRV_HANDLE) 0)
```

Module

RSA

Description

Definition for a single drive handle for the software-only RSA module

1.7.6.2 DRV_RSA_INDEX Macro

File

rsa.h

Syntax

```
#define DRV_RSA_INDEX DRV_RSA_INDEX_0
```

Module

RSA

Description

Map of the default drive index to drive index 0

1.7.6.3 DRV_RSA_INDEX_0 Macro

File

rsa.h

Syntax

```
#define DRV_RSA_INDEX_0 0
```

Module

RSA

Description

Definition for a single drive index for the software-only RSA module

1.7.6.4 DRV_RSA_INDEX_COUNT Macro

File

rsa.h

Syntax

```
#define DRV_RSA_INDEX_COUNT 1
```

Module

RSA

Description

Number of drive indicies for this module

1.7.6.5 RSA_MODULE_ID Type

File

rsa.h

Syntax

```
typedef uint8_t RSA_MODULE_ID;
```

Module

RSA

Description

This is type RSA_MODULE_ID.

1.7.6.6 DRV_RSA_INIT Structure

File

rsa.h

Syntax

```
typedef struct {
    SYS_MODULE_INIT moduleInit;
    RSA_MODULE_ID rsaID;
    uint8_t operationMode;
    uint8_t initFlags;
} DRV_RSA_INIT;
```

Members

Members	Description
SYS_MODULE_INIT moduleInit;	System module initialization
RSA_MODULE_ID rsaID;	Identifies RSA hardware module (PLIB-level) ID

uint8_t operationMode;	Operation Modes of the driver
uint8_t initFlags;	Flags for the rsa initialization

Module

RSA

Description

Initialization structure used for RSA.

1.7.6.7 DRV_RSA_OPERATION_MODES Enumeration

File

rsa.h

Syntax

```
typedef enum {
    DRV_RSA_OPERATION_MODE_NONE = (1 << 0),
    DRV_RSA_OPERATION_MODE_ENCRYPT = (1 << 1),
    DRV_RSA_OPERATION_MODE_DECRYPT = (1 << 2)
} DRV_RSA_OPERATION_MODES;
```

Members

Members	Description
DRV_RSA_OPERATION_MODE_NONE = (1 << 0)	RS232 Mode (Asynchronous Mode of Operation)
DRV_RSA_OPERATION_MODE_ENCRYPT = (1 << 1)	RS232 Mode (Asynchronous Mode of Operation)
DRV_RSA_OPERATION_MODE_DECRYPT = (1 << 2)	RS485 Mode (Asynchronous Mode of Operation)

Module

RSA

Description

Enumeration describing modes of operation used with RSA

1.7.6.8 DRV_RSA_PAD_TYPE Enumeration

File

rsa.h

Syntax

```
typedef enum {
    DRV_RSA_PAD_DEFAULT,
    DRV_RSA_PAD_PKCS1
} DRV_RSA_PAD_TYPE;
```

Members

Members	Description
DRV_RSA_PAD_DEFAULT	Use default padding
DRV_RSA_PAD_PKCS1	Use the PKCS1 padding format

Module

RSA

Description

Enumeration describing the padding type that should be used with a message being encrypted

1.7.6.9 DRV_RSA_PUBLIC_KEY Structure

File

rsa.h

Syntax

```
typedef struct {
    int nLen;
    uint8_t* n;
    int eLen;
    uint8_t* exp;
} DRV_RSA_PUBLIC_KEY;
```

Members

Members	Description
int nLen;	key length, in bytes
uint8_t* n;	public modulus
int eLen;	exponent length, in bytes
uint8_t* exp;	public exponent

Module

RSA

Description

Structure describing the format of an RSA public key (used for encryption or verification)

1.7.6.10 DRV_RSA_PRIVATE_KEY_CRT Structure

File

rsa.h

Syntax

```
typedef struct {
    int nLen;
    uint8_t* P;
    uint8_t* Q;
    uint8_t* dP;
    uint8_t* dQ;
    uint8_t* qInv;
} DRV_RSA_PRIVATE_KEY_CRT;
```

Members

Members	Description
int nLen;	key length, in bytes
uint8_t* P;	CRT "P" parameter
uint8_t* Q;	CRT "Q" parameter
uint8_t* dP;	CRT "dP" parameter
uint8_t* dQ;	CRT "dQ" parameter
uint8_t* qInv;	CRT "qInv" parameter

Module

RSA

Description

Structure describing the format of an RSA private key, in CRT format (used for decryption or signing)

1.7.6.11 DRV_RSA_STATUS Enumeration

File

rsa.h

Syntax

```
typedef enum {
    DRV_RSA_STATUS_OPEN = DRV_CLIENT_STATUS_READY+3,
    DRV_RSA_STATUS_INIT = DRV_CLIENT_STATUS_READY+2,
    DRV_RSA_STATUS_READY = DRV_CLIENT_STATUS_READY+0,
    DRV_RSA_STATUS_BUSY = DRV_CLIENT_STATUS_BUSY,
    DRV_RSA_STATUS_ERROR = DRV_CLIENT_STATUS_ERROR-0,
    DRV_RSA_STATUS_INVALID = DRV_CLIENT_STATUS_ERROR-1,
    DRV_RSA_STATUS_BAD_PARAM = DRV_CLIENT_STATUS_ERROR-2
} DRV_RSA_STATUS;
```

Members

Members	Description
DRV_RSA_STATUS_OPEN = DRV_CLIENT_STATUS_READY+3	Driver open, but not configured by client
DRV_RSA_STATUS_INIT = DRV_CLIENT_STATUS_READY+2	Driver initialized, but not opened by client
DRV_RSA_STATUS_READY = DRV_CLIENT_STATUS_READY+0	Open and configured, ready to start new operation
DRV_RSA_STATUS_BUSY = DRV_CLIENT_STATUS_BUSY	Operation in progress, unable to start a new one
DRV_RSA_STATUS_ERROR = DRV_CLIENT_STATUS_ERROR-0	Error Occured
DRV_RSA_STATUS_INVALID = DRV_CLIENT_STATUS_ERROR-1	client Invalid or driver not initialized
DRV_RSA_STATUS_BAD_PARAM = DRV_CLIENT_STATUS_ERROR-2	client Invalid or driver not initialized

Module

RSA

Description

Enumeration describing statuses that could apply to an RSA operation

1.7.6.12 RSA_RandomGet Type

File

rsa.h

Syntax

```
typedef DRV_RSA_RandomGet RSA_RandomGet;
```

Module

RSA

Description

Global variable for the rand function used with this library.

1.7.6.13 DRV_RSA_Initialize Function

Initializes the data for the instance of the RSA module

File

rsa.h

Syntax

```
SYS_MODULE_OBJ DRV_RSA_Initialize(const SYS_MODULE_INDEX index, const SYS_MODULE_INIT *  
const init);
```

Module

RSA

Returns

If successful, returns a valid handle to a driver instance object. Otherwise, it returns SYS_MODULE_OBJ_INVALID

Description

This routine initializes data for the instance of the RSA module.

Preconditions

None

Parameters

Parameters	Description
index	Identifier for the instance to be initialized
init	Pointer to the data structure containing any data necessary to initialize the hardware. This pointer may be null if no data is required and default initialization is to be used

Function

```
SYS_MODULE_OBJ DRV_RSA_Initialize(const SYS_MODULE_INDEX index,  
const SYS_MODULE_INIT * const init)
```

1.7.6.14 DRV_RSA_Deinitialize Function

Deinitializes the instance of the RSA module

File

rsa.h

Syntax

```
void DRV_RSA_Deinitialize(SYS_MODULE_OBJ object);
```

Module

RSA

Returns

None

Description

Deinitializes the specific module instance disabling its operation. Resets all the internal data structures and fields for the specified instance to the default settings.

Preconditions

None

Parameters

Parameters	Description
object	Identifier for the instance to be de-initialized

Function

```
void DRV_RSA_Deinitialize(SYS_MODULE_OBJ object)
```

1.7.6.15 DRV_RSA_Open Function

Opens a new client for the device instance

File

rsa.h

Syntax

```
DRV_HANDLE DRV_RSA_Open(const SYS_MODULE_INDEX index, const DRV_IO_INTENT ioIntent);
```

Module

RSA

Returns

None

Description

Returns a handle of the opened client instance. All client operation APIs will require this handle as an argument

Preconditions

The driver must have been previously initialized and in the initialized state.

Parameters

Parameters	Description
index	Identifier for the instance to opened
ioIntent	Possible values from the enumeration DRV_IO_INTENT Used to specify blocking or non-blocking mode

Function

```
DRV_HANDLE DRV_RSA_Open(const SYS_MODULE_INDEX index,
const DRV_IO_INTENT ioIntent)
```

1.7.6.16 DRV_RSA_Close Function

Closes an opened client

File

rsa.h

Syntax

```
void DRV_RSA_Close(DRV_HANDLE handle);
```

Module

RSA

Returns

None

Description

Closes an opened client, resets the data structure and removes the client from the driver.

Preconditions

None.

Parameters

Parameters	Description
handle	The handle of the opened client instance returned by DRV_RSA_Open().

Function

void DRV_RSA_Close (DRV_HANDLE handle)

1.7.6.17 DRV_RSA_Configure Function

Configures the client instance

File

rsa.h

Syntax

```
int DRV_RSA_Configure(DRV_HANDLE h, uint8_t * xBuffer, uint8_t * yBuffer, uint16_t xLen,
                      uint16_t yLen, DRV_RSA_RandomGet randFunc, DRV_RSA_PAD_TYPE padType);
```

Module

RSA

Returns

0 if successful; 1 if not successful

Description

Configures the client instance data structure with information needed by the encrypt/decrypt routines

Remarks

In the dsPIC implementation the xBuffer should be twice as large as the key length, located in x-memory, and be 64-byte aligned. The yBuffer should be three times as large as the key length, located in y-memory, and be 2-byte aligned. In the other implementations, xBuffer and yBuffer should both be 4-byte aligned and should both be twice the size of the key length.

DRV_RSA_PAD_DEFAULT is currently the only supported type of padding

Preconditions

Driver must be opened by a client.

Parameters

Parameters	Description
handle	The handle of the opened client instance.
xBuffer	A pointer to a working buffer needed by the encrypt/decrypt routines.
yBuffer	A pointer to a working buffer needed by the encrypt/decrypt routines
xLen	The size (in bytes) of xBuffer
yLen	The size (in bytes) of yBuffer

randFunc	A pointer to a function used to generate random numbers for message padding.
padType	The type of padding requested.

Function

```
int DRV_RSA_Configure(DRV_HANDLE handle, uint8_t *xBuffer, uint8_t *yBuffer,
int xLen, int yLen,           DRV_RSA_RandomGet randFunc,
DRV_RSA_PAD_TYPE padType)
```

1.7.6.18 DRV_RSA_RandomGet Type

File

rsa.h

Syntax

```
typedef uint32_t (* DRV_RSA_RandomGet) (void);
```

Module

RSA

Description

Function pointer for the rand function type.

1.7.6.19 DRV_RSA_Encrypt Function

Encrypts a message using a public RSA key

File

rsa.h

Syntax

```
DRV_RSA_STATUS DRV_RSA_Encrypt(DRV_HANDLE handle, uint8_t * cipherText, uint8_t *  
plainText, uint16_t msgLen, const DRV_RSA_PUBLIC_KEY * publicKey);
```

Module

RSA

Returns

Driver status. If running in blocking mode, the function will return DRV_RSA_STATUS_READY after a successful encryption operation. If running in non-blocking mode, the driver will start the encryption operation and return immediately with DRV_RSA_STATUS_BUSY.

Description

This routine encrypts a message using a public RSA key.

Remarks

The plainText and cipherText buffers must be at least as large as the key size

The message length must not be greater than the key size

Preconditions

Driver must be opened by a client.

Parameters

Parameters	Description
handle	The handle of the opened client instance
cipherText	A pointer to a buffer that will hold the encrypted message
plainText	A pointer to the buffer containing the message to be encrypted
msgLen	The length of the message to be encrypted
publicKey	A pointer to a structure containing the public key

Function

```
DRV_RSA_STATUS DRV_RSA_Encrypt (DRV_HANDLE handle, uint8_t *cipherText,
                                uint8_t *plainText, int msgLen,
                                const DRV_RSA_PUBLIC_KEY *publicKey)
```

1.7.6.20 DRV_RSA_Decrypt Function

Decrypts a message using a private RSA key

File

rsa.h

Syntax

```
DRV_RSA_STATUS DRV_RSA_Decrypt (DRV_HANDLE handle, uint8_t * plainText, uint8_t * cipherText, uint16_t * msgLen, const DRV_RSA_PRIVATE_KEY_CRT * privateKey);
```

Module

RSA

Returns

Driver status. If running in blocking mode, the function will return DRV_RSA_STATUS_READY after a successful decryption operation. If running in non-blocking mode, the driver will start the decryption operation and return immediately with DRV_RSA_STATUS_BUSY.

Description

This routine decrypts a message using a private RSA key.

Remarks

The plainText and cipherText buffers must be at least as large as the key size

The message length must not be greater than the key size

Preconditions

Driver must be opened by a client.

Parameters

Parameters	Description
handle	The handle of the opened client instance
plainText	A pointer to a buffer that will hold the decrypted message
cipherText	A pointer to a buffer containing the message to be decrypted
msgLen	The length of the message that was decrypted
privateKey	A pointer to a structure containing the public key

Function

```
DRV_RSA_STATUS DRV_RSA_Decrypt (DRV_HANDLE handle, uint8_t *plainText,
```

```
uint8_t *cipherText, int * msgLen,  
const DRV_RSA_PRIVATE_KEY_CRT *privateKey)
```

1.7.6.21 DRV_RSA_Tasks Function

Maintains the driver's state machine by advancing a non-blocking encryption or decryption operation.

File

rsa.h

Syntax

```
void DRV_RSA_Tasks(SYS_MODULE_OBJ object);
```

Module

RSA

Returns

None.

Description

This routine maintains the driver's state machine by advancing a non-blocking encryption or decryption operation.

Preconditions

Driver must be opened by a client.

Parameters

Parameters	Description
object	Object handle for the specified driver instance

Function

```
void DRV_RSA_Tasks(SYS_MODULE_OBJ object)
```

1.7.6.22 DRV_RSA_ClientStatus Function

Returns the current state of the encryption/decryption operation

File

rsa.h

Syntax

```
DRV_RSA_STATUS DRV_RSA_ClientStatus(DRV_HANDLE handle);
```

Module

RSA

Returns

Driver status (the current status of the encryption/decryption operation).

Description

This routine returns the current state of the encryption/decryption operation.

Preconditions

Driver must be opened by a client.

Parameters

Parameters	Description
handle	The handle of the opened client instance

Function

DRV_RSA_STATUS DRV_RSA_ClientStatus(DRV_HANDLE handle)

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